**July 10, 1998 DRAFT**

## C&SF RESTUDY ALTERNATIVE EVALUATION TEAM REPORT
## ON THE
## PLAN FORMULATION ALTERNATIVES A – D13R

***Prepared by the C&SF Restudy Alternative Evaluation Team***

### Introduction

Starting in September 1997, the Restudy team engaged in developing alternative comprehensive plans. During this phase, two base conditions (1995 and 2050) and six alternatives (starting point and alternatives 1 - 5) were formulated and evaluated. The results of each of these evaluations were documented and posted on the Restudy webpage as AET reports. Plan 6 was formulated but was not evaluated as such for the reasons that follow.

This alternative development phase was an iterative process in which each alternative plan was formulated as a result of the evaluation of the previous alternative. The iterative nature of this phase allowed both the Alternative Evaluation Team (AET) and the Alternative Development Team (ADT) to learn more about the particular components of the plans including how the components performed under a range of conditions. Further, use of the Internet provided a media by which to solicit considerable agency and public comment. It also gave the teams additional information about the components in regard to engineering and technical feasibility. Therefore, as the teams progressed with formulation of the alternatives, knowledge gained from this process resulted in a refinement (structural and operational) of components in later alternatives. Modifications to the components, however, created an inconsistency between the alternatives. Thus when comparing the alternatives against each other, evaluation results naturally favored the later alternatives.

To make the alternatives more comparable, the earlier alternatives were modified to account for these changes. Further, issues with regard to certain elements in the base conditions were also identified and addressed prior to the final evaluation of the alternatives. Since the base conditions were modified, the results of Alternative 6 were not evaluated against the previous model runs (as this would have been like comparing apples to oranges). Therefore, the alternatives evaluated in the "last round" were distinguished using a different nomenclature, (i.e., Plan A (3 revised), B (4 revised), C (5 revised), and D (6)). The changes to the earlier alternatives improved performance and at the same time, equalized the uncertainties between the plans. Since refined base conditions were used in this series of model simulations, the evaluation had to be clearly differentiated from the previous task by using the different nomenclature.

The end result of this final evaluation has been the development of an evaluation matrix that will display Alternatives A – D and the 2050 Base condition, and Alternatives D, D13R, and the 2050 Base Case.

**AET Evaluation and Comparison of Alternative Plans A – D13R**

The AET met 21-22 and 26-28 May 1998, to evaluate and compare the 1995 and 2050 Bases and Alternative Plans A through D. This report summarizes the results of these evaluations, and how the Initial Draft Plan became D13R.

The AET used a set of approximately 25 different matrices as a basis for organizing large numbers of scores for the two base cases and four alternative plans. The documentation and interpretation for these matrices are described in each of the individual subteam's reports, which follow this introduction. Certain references that pertain to documentation of the matrices can be found in Attachment A of this document. The numerical scores presented in these matrices were derived from a set of ecological, water supply and flood protection performance measures. These performance measures were developed by the AET during the alternative plan evaluation process, conducted between September 1997 and May 1998. The matrices allowed comparisons among the two bases and four alternative plans, for purposes of ranking the different plans, and to evaluate how well each plan performed relative to, (1) the targets defined by the performance measures and (2) the performance of the 2050 Base (future without project condition).

The AET used three different evaluation criteria to compare the four alternative plans (A – D)and the 2050 Base: (1) plan ranking, (2) plan grade, and (3) plan color. These three evaluation criteria were derived from the numerical scores in the matrices. (1) Plan rankings were created by converting the five numerical scores calculated for each performance measure or set of measures (one for each plan and the base case), into ordinal scores, and then tallying all ordinal scores for each plan and the base case. The plan with the lowest cumulative score received the overall highest rank, i.e., is overall better than other plans in meeting the performance measure targets. (2) Plan grades were created by grouping the numerical scores, and assigning a common letter grade to all numerical scores within each grouping. The letter grades indicate how well each alternative plan and the 2050 Base performed at meeting the numerical targets set by the performance measures. More than one plan could receive a similar grade, for a common set of performance measures, if two or more plans performed similarly for those measures. The grades are A, B, C, D, and F. (3) Plan colors (green, yellow, and red) were created by converting plan grades into a "best professional opinion" prediction by the members of each subteam on how likely each plan and base case would achieve the long-term ecological or water supply objectives which are identified for each performance measure. Each color provides two kinds of information: (a) a prediction of how likely a plan will achieve the recovery and long-term sustainability objectives defined by the performance measure(s), and (b) a recommended priority for further improvement in the design and operation of the currently modeled plan. Green means that the current plan is likely to recover and sustain the ecological or water supply objective described by the performance measures, and that further plan improvement is unnecessary or a low priority. Yellow means that achievement of the long-term objectives is uncertain, and that improvement in the plan is a moderate priority. Red means that the recovery and long-term sustainability of the target objective are unlikely, and that the current plan requires improvement if these targets are to be met.

Plan evaluations were not based directly on the numerical scores in the matrices because the team was unanimous in its opinion that numerical scores imply a level of precision in the evaluations that is not possible with the modeling tools and the understandings of ecological and physical systems that are currently available. The team also agreed that numerical scores should only be compared where similar computational methods were used, and/or similar hydrological parameters were being evaluated.

Because of spatial limitations in the water quality models and performance measures, the water quality evaluations were restricted to Lake Okeechobee, the EAA, the St. Lucie and Caloosahatchee watersheds, Loxahatchee NWR, WCAs 2 and 3, mainland Everglades National Park and the Lower East Coast Service Areas. Water quality rankings and grades, but not color evaluations, were prepared for these subregions.

The results from these three evaluations are presented in Tables 1 – 4. The first three tables (Tables 1-3) present the plan rankings, grades and color codes for all matrices (all ecological and water supply performance measures). Table 4 represents a ranking for ALTSS & Listed Species.

Tables 1-3 agree in showing that Alternative D is the best overall plan for meeting the performance measures. For these same criteria, Alternative C is the second best plan. Table 4 shows that for Listed Species, Alternative D ranks slightly higher than the other alternatives, with Alternative C ranking second. All tables show that for almost all performance measures, one or more plans provide substantial benefits (i.e., improvements) over the 2050 Base.

The AET recommended Alternative D, with the proviso that steps be taken to correct specific weaknesses in the alternative. Overall, Alternative D performed best for Lake Okeechobee, the Caloosahatchee Estuary, the Lake Okeechobee Service Area, the Lower East Coast, Loxahatchee NWR, the Holey Land and Rotenberger WMAs, the southern and southeastern Big Cypress basin, and the southern Everglades Rocky Glades. Alternative D, as modeled, was inadequate for meeting performance targets in WCAs 2 and 3, and Shark Slough (reds in Table 3), and was only moderately adequate at meeting targets for the St. Lucie Estuary and Florida Bay (yellows). The AET recommended that ad hoc teams of ecologists, hydrologists and modelers be created to determine both the immediate and long-term strategy for improving the performance of Alternative D in the red and yellow scored areas.

The AET also highlighted three specific strengths of Alternative B, which, if incorporated into Alternative D, would bring the different ecological strengths of these two plans together in a single final plan. These plan B strengths were, (1) the higher volumes of flow into the Florida Bay estuary compared to other plans, (2) the greater success at reestablishing system connectivity, and (3) the improved levels of sheet flow, compared to other plans. These three features were a consequence of the greater extent of system-wide decompartmentalization, which characterized Alternative B. The AET recommended that an ad hoc team explore the feasibility of merging these features of B into D.

| Table 1 - Performance of the 2050 Base and Alternatives Based on Relative Ranking. | | | | | |
|---|---|---|---|---|---|
| **All Subregions** | | | | | |
| **RELATIVE RANKING** | | | | | |
| (1=best, 5=worse) | | | | | |
| **Subregion** | **2050** | **Alt A** | **Alt B** | **Alt C** | **Alt D** |
| LOSA | 5 | 3 | 4 | 2 | 1 |
| LECSA | 5 | 3.5 | 3.5 | 1.5 | 1.5 |
| Lake Okeechobee | 5 | 3.5 | 3.5 | 1.5 | 1.5 |
| St Lucie Estuary | 5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Caloosahatchee Estuary | 5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Lake Worth Lagoon | 5 | 4 | 1 | 2.5 | 2.5 |
| LNWR | 5 | 4 | 2 | 2 | 2 |
| Shark River Slough | 5 | 4 | 1.5 | 3 | 1.5 |
| WCA 2 & 3 | 5 | 1 | 3 | 3 | 3 |
| Holeyland & Rotenberger | 3 | 3 | 3 | 3 | 3 |
| Rockland Marl Marsh | 5 | 3.5 | 3.5 | 2 | 1 |
| Florida Bay | 5 | 1.5 | 1.5 | 3.5 | 3.5 |
| C-111 Basin | 4 | 5 | 2 | 2.5 | 1.5 |
| SW Dade Agricultural Area | 5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Biscayne Bay | 2.7 | 4.3 | 4.3 | 2.2 | 1.5 |
| No Big Cypress | 4 | 4 | 4 | 1.5 | 1.5 |
| So Big Cypress | 4 | 4 | 4 | 2 | 1 |
| SE Big Cypress | 5 | 2 | 4 | 2 | 2 |
| Connectivity | 5 | 4 | 1 | 2 | 3 |
| Sheet Flow | 5 | 4 | 1 | 2.5 | 2.5 |
| Fragmentation | 4.5 | 4.5 | 1 | 2.5 | 2.5 |
| Water Quality | 5 | 3.5 | 3.5 | 1.5 | 1.5 |
| | | | | | |
| **Total Sum of Rankings** | **102.2** | **73.8** | **58.8** | **50.2** | **45** |

| Table 2 - Performance of the 2050 Base and Alternatives Relative to Performance Measures. | | | | | |
|---|---|---|---|---|---|
| **All Subregions<br>LETTER GRADE** | | | | | |
| A=4pts, B=3pts, C=2pts, D=1pt, F=0pts | | | | | |
| **Subregion** | **2050** | **Alt A** | **Alt B** | **Alt C** | **Alt D** |
| LOSA | F | B | C | B | A |
| LECSA | D | B | B | A | A |
| Lake Okeechobee | C | B | B | A | A |
| St Lucie Estuary | F | C | C | C | C |
| Caloosahatchee Estuary | F | A | A | A | A |
| Lake Worth Lagoon | F | D | B | C | C |
| LNWR | C | A | A | A | A |
| Shark River Slough | F | F | D | D | D |
| WCA 2 & 3 | D | C | D | D | D |
| Holey land & Rotenberger | C | B | B | B | B |
| Rockland Marl Marsh | D | C | C | B | B |
| Florida Bay | F | C | C | C | C |
| C-111 Basin | F | F | C | B | B |
| SW Dade Agricultural Area | F | A | A | A | B |
| Biscayne Bay | C | F | F | C | B |
| No Big Cypress | F | F | F | D | D |
| So Big Cypress | B | B | B | B | A |
| SE Big Cypress | B | A | B | A | A |
| Connectivity | D | D | A | B | B |
| Sheet Flow | F | B | B | B | B |
| Fragmentation | F | F | A | B | B |
| Water Quality | D | C | C | C | C |

| Table 3 - Performance of the 2050 Base and Alternatives to Achieve Long-Term Objectives | | | | | |
|---|---|---|---|---|---|
| **All Subregions** | | | | | |
| **COLOR RANKING** | | | | | |
| green=successful, yellow=marginal or uncertain, red=unsucessful | | | | | |
| **Subregion** | **2050** | **Alt A** | **Alt B** | **Alt C** | **Alt D** |
| LOSA | R | G | Y | G | G |
| LECSA | R | Y | Y | G | G |
| Lake Okeechobee | Y | G | G | G | G |
| St Lucie Estuary | R | Y | Y | Y | Y |
| Caloosahatchee Estuary | R | G | G | G | G |
| Lake Worth Lagoon | Y | R | R | Y | Y |
| LNWR | Y | G | G | G | G |
| Shark River Slough | R | R | R | R | R |
| WCA 2 & 3 | R | Y | R | R | R |
| Holeyland & Rotenberger | Y | G | G | G | G |
| Rockland Marl Marsh | R | Y | Y | G | G |
| Florida Bay | R | Y | Y | Y | Y |
| C-111 Basin | R | R | Y | G | G |
| SW Dade Agricultural Area | R | G | G | G | Y |
| Biscayne Bay | Y | R | R | Y | G |
| No Big Cypress | R | R | R | R | R |
| So Big Cypress | Y | Y | Y | Y | G |
| SE Big Cypress | Y | G | Y | G | G |
| Connectivity | Y | Y | G | G | G |
| Sheet Flow | R | G | G | G | G |
| Fragmentation | R | R | G | G | G |

**Selection and Refinement of Initial Draft Plan**

At the Restudy meeting the week of June 2, an initial draft plan, Alternative D, was selected. The full team accepted the AET recommendation that Alternative D needed refinement to improve its performance in some areas. Five key areas, WCA-2, WCA-3, Shark River Slough, Florida Bay, and the St. Lucie Estuary were identified as areas where improvements should be made.

During the 11-day period from June 5-15, 1998 a team of engineers and ecologists conducted an intense iterative process to attempt to improve the hydrologic performance of Alternative D in the WCAs and Everglades National Park. During this week and a half, many refinements to operations and structures were made to Alternative D. Initially, the refinements consisted of only operational changes (iterations D1-D7); these proved inadequate to meet the desired performance. It was decided that structural changes were necessary, resulting in model runs D8-D13R. The final iteration, D13R, represents refinements to the initial draft plan that improve its performance in the remaining Everglades, to provide for a sustainable Everglades ecosystem and move towards restoration.

The fifth area identified by the AET and full Restudy Team where improvement was warranted was the St. Lucie Estuary. During the same time period that the Everglades team was working, Indian River Lagoon Feasibility Study modelers were able to substantially improve the St. Lucie Estuary performance by increasing storage in the C-23, C-24, North Fork and South Fork basins as well as making refinements to the estuary triggers.

Refinements made to the initial draft plan indicated major improvements in the WCAs and Everglades National Park without compromising Lake Okeechobee water levels or water supply to LOSA and LECSA. The modifications relieved adverse high and low water conditions in the WCAs. Flow volumes to Shark River Slough were increased while seasonal distribution of flows as indicated by NSM was maintained. The number of drydowns in Shark River Slough was reduced to three events over the period of record compared to two events under NSM. Salinity in Florida Bay coastal basins as indicated by P33 stages was improved as well. These improvements were achieved through partial decompartmentalization of WCA-3 and the park, which makes Alternative D13R more like Alternative B as desired by the AET and the Restudy Team. Performance in the St. Lucie Estuary came closer to meeting targets, especially in local basin runoff.

Table 5 is a summary table of letter grades for the 2050 Base Case, and Initial Draft Plans D – D13R. Table 6 shows the same for color ranking.

Table 5 - Letter Grades

Performance of 2050 Base and Initial Draft Plans D - D13R Relative to Ecological Performance Measures

LETTER GRADE

| **Subregion** | **2050** | **Alt D** | **D13R** |
|---|---|---|---|
| Lake Okeechobee | C | A | A |
| St Lucie Estuary | F | C | C |
| Caloosahatchee Estuary | F | A | A |
| Lake Worth Lagoon | | C | C |
| Loxahatchee NWR | C | A | A |
| Holeyland & Rotenberger | C | B | B |
| WCA 2A | D | D | C |
| WCA 2B | | F | F |
| Northwestern WCA 3A | | B | B |
| Northeasten WCA 3A | | F | D |
| Eastern WCA 3A | | F | D |
| Central & Southern WCA 3A | | D | B |
| WCA 3B | | F | C |
| Shark River Slough | F | D | B |
| Rockland Marl Marsh | D | B | B |
| Biscayne Bay | C | B | B |
| Florida Bay | F | C | B |
| Pennsuco | | B | B |
| C-111 Basin | F | B | B |
| So Big Cypress | B | A | A |
| SE Big Cypress | B | A | A |
| Connectivity | D | B | B+ |
| Sheet Flow | F | B | B |
| Fragmentation | F | B | A |

Table 6 - Color Ranking

| Performance of the 2050 Base,Initial Draft Plans D - D13R to Achieve Long-Term Ecological Objectives | | | |
|---|---|---|---|
| COLOR RANKING | | | |
| **Subregion** | **2050** | **Alt D** | **D13R** |
| Lake Okeechobee | Y | G | G |
| St Lucie Estuary | R | Y | G |
| Caloosahatchee Estuary | R | G | G |
| Lake Worth Lagoon | Y | Y | Y |
| Loxahatchee NWR | Y | G | G |
| Holeyland & Rotenberger | Y | G | G |
| WCA 2A | R | R/Y | G/Y |
| WCA 2B | | R | R |
| Northwestern WCA 3A | | G | G |
| Northeasten WCA 3A | | R | Y |
| Eastern WCA 3A | | R | Y |
| Central & Southern WCA 3A | | R/Y | G/Y |
| WCA 3B | | R | Y |
| Shark River Slough | R | R | G |
| Rockland Marl Marsh | R | G | Y |
| Biscayne Bay | Y | G | G |
| Florida Bay | R | Y | G |
| Pennsuco | | G | G |
| C-111 Basin | R | G | G |
| So Big Cypress | Y | G | G |
| SE Big Cypress | Y | G | G |
| Connectivity | Y | G | G |
| Sheet Flow | R | G | G |
| Fragmentation | R | G | G |

**Subteam Reports on Alternatives A – D13R**

## A. Total System Subteam Decompartmentalization Matrix

### Continuity: Water Surface Elevations Across Barriers

Justification

One of the problems resulting from using canals and levees to improve water management for water supply and flood control is that water surface elevations on either side of the barriers tend to be very different, i.e. pooling upstream and too dry downstream. The physical disconnection of the two wet areas is not addressed by this index but is addressed in the sheetflow index. The direct effects of pooling and drying on wildlife are addressed in the various measures of hydroperiod and ponding depths within each subregion group. This index addresses the discontinuity in water surface elevations and the effects of unexpected conditions on aquatic organisms and the species that rely on them. Different species of wading birds, for example, rely on various depths of shallow marsh to allow them to capture prey. Abrupt changes in depth, one too deep and one too shallow, limit their feeding area. This index is limited because, by using water level differences >0.5 feet as the top category, differences far greater than that are scored no worse than.

Performance Measures

1. Count of Water Level Differences Relative to NSM Water Level Differences for eight different man-made barriers within the remaining Everglades.

Strategy for Developing Indices

The Count of Water Level Differences illustrates the number of weeks where the difference in water surface elevations across the barriers exceed the difference predicted by NSM 4.5F by 1) <0.25 feet, 2) <0.5 feet and 3) > 0.5 feet. Using that data, the following formulas were used:

1. To get an index score that rated highly a large number of weeks where differences in elevations were similar to NSM, this formula was used:

   exp(-(x-1612)^2/2*w2)), where w = 900 and x = number of weeks where water surface elevation differences differed from NSM < 0.25 feet.

2. To get an index score that rated highly a low number of weeks where differences were more than 0.5 feet greater than NSM, the inverse of the formula was used:

   1 – [exp(-(x-1612)^2/2*w2))], where w = 900 and x = number of weeks were water surface elevation differences differed from NSM > 0.5 feet.

Using these formulas, the highest scores were received by plans with the highest number of weeks that differed little from NSM *and* the lowest number of weeks differing greatly from

NSM. This was done to avoid excluding the intermediate category containing the number of weeks where water level differences were >0.25 feet and <0.5 feet. The two scores were combined by averaging the two values; no weighting was involved. Weighting could have been added to the equation by using a different value for "w" depending on how far above 0.5 feet the difference was. In some cases, it was up to four feet greater than NSM.

Results

Flows through the northern part of the system across L-39 (between Loxahatchee NWR and WCA-2A) and L-38 (between WCA-2A and WCA-3A) remained unchanged between alternatives because the AET chose not to include them in any of the decompartmentalization scenarios. For that reason, their scores remained at zero throughout the analysis. Miami Canal North (MCN) improved slightly in alternatives B, C, and D. Miami Canal South (MCS) remained the same throughout and received a consistent score of 1.0. L-67 scored the best in Alternative B, the alternative in which it was completely removed. Alternatives C and D used other methods, including weirs, to operate flows across the L-67 barrier but were unsuccessful at reaching NSM-like water surface elevations on both sides of the barrier. These results must be tempered with the knowledge that the weirs may still operate successfully once their configuration and operation have been optimized. At the time, there had not been much chance to do so. Tamiami Trail west of L-67 (TTW) received its best score under Alternative B where it was completely removed. Alternatives C and D had fairly good scores with improved operations of the reinstalled structures. Tamiami Trail east (TTE) was removed in alternatives B, C and D and received a 1.0 for those three. L-28 received its best scores in alternatives B and C, although Alternative A and the 2050 Base received a 0.9.

In the table below, AVE1 is the average of the scores for the barriers excluding L-39 and L-38. This was an attempt to see the effect of these two very low scores on the final scores. AVE2 is an average of all eight scores. The AET decided to use AVE1 on which to base its color and grade and ranking scores in order to receive the benefits of the decompartmentalization that did occur. However, it should be noted AVE2 illustrates the overall system-wide benefit to the system, which only improves with alternatives B and D13R.

In Alternative D13R, the differences between water surface elevations on either sides of barriers inside of the remaining natural areas were more like NSM than the 2050 Base. As in Alternative B, the upstream pooling effects disappeared when barriers like Miami Canal, Tamiami Trail and L-28 are removed, but, unlike Alternative B, water flows more evenly throughout the system than it did in the 2050 Base. The removal of the southern portion of L-67 improved the continuity score a small amount.

**Continuity: Water Surface Elevational Differences across Barriers**

| | 95 | 50 | A | B | C | D | D13R |
|---|---|---|---|---|---|---|---|
| L-39 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| L-38 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MCN | 0.1 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| MCS | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| L-67 | 0.0 | 0.1 | 0.1 | 1.0 | 0.1 | 0.1 | 0.2 |
| TTW | 0.0 | 0.4 | 0.3 | 1.0 | 0.6 | 0.6 | 1.0 |
| TTE | 0.5 | 0.7 | 0.6 | 1.0 | 1.0 | 1.0 | 1.0 |
| L-28 | 0.6 | 0.9 | 0.9 | 1.0 | 1.0 | 0.7 | 1.0 |
| AVE1 | 0.4 | 0.4 | 0.4 | 0.9 | 0.7 | 0.6 | 0.8 |
| AVE2 | 0.3 | 0.3 | 0.4 | 0.7 | 0.4 | 0.4 | 0.6 |
| Color | - | Yellow | Yellow | Green | Green | Green | Green |
| Grade | - | D | D | A | B | B | B+ |
| Rank | - | 5 | 4 | 1 | 2 | 3 | - |

**Sheetflow: Flow Volume Transects**

Justification

The natural system hydrology model (Fennema et al., Chapter 10) indicates that water management produced a significant change in the overland flow patterns in the Everglades. The Everglades was generally more of a flowing system with greater spatial extent and longer periods of inundation than exist today. Regional sheetflow patterns have been significantly disrupted and overland flow volumes reduced by the impoundment of Lake Okeechobee, construction of WCA levees and irrigation / drainage canals in the EAA, and the loss of dry season lag flows from the dense sawgrass plain that formerly covered the present EAA. Flow patterns out of Lake Okeechobee have shifted from primarily wet season flows in response to rainfall to dry season flows in response to urban and agricultural water supply demands.

Impoundment of water in the WCAs and diversion of surface water flows to the east, combined with ground water and levee seepage loses eastward in the modified system, have significantly contributed to reduced flows and the resultant loss of persistent hydroperiods in southern Everglades (Davis and Ogden 1994).

Instead of a vast expanse of sheetflow, the Everglades has become a series of pools, with pooling on the upstream and excess drying on the downstream side of barriers. “Ponded systems favor certain species and flowing systems favor others. There are many physicochemical differences in the two systems: food types and sources, migration of macroinvertebrates, dispersion of nutrients, aeration and diffusion of gases in water, particulate suspension, and thermal stratification are some examples. Ponding in the WCAs amounts to regulation for certain species—the zoo approach, which is not an ecosystem approach. From a water conservation perspective, ponding may be wise; and in a water-limited system, ponded water for fish is a real improvement over no water for fish. It would be possible to match regulated hydroperiods month to month with natural hydroperiods and still have a completely different ecosystem due to the difference in water movement. This is another reason why a hydroperiod analysis is singularly insufficient to create the intended biological conditions.” (US Army Corps of Engineers, 1994).

Sheetflow also shapes tree islands, supports microhabitats on the upstream and downstream sides, enhances the uptake of nutrients from the water column and creates an environment that precipitated phosphorus, along with calcium carbonate, into the substrate.

Performance Measure

1. Flow volume across transects

Strategy for Developing Indices

The 26 transects were grouped into five categories representing their general area: Big Cypress Group (T24, T25, T26), Central Everglades (WCA-3A) Group (T7, T8, T12), Southern Everglades Group (T21, T23A, B, &C), Tamiami Trail Group (T17, T18) and the L-67 Group (T13, T14). For each group, an index was calculated for each transect based on the wet season and the dry season average annual overland flows. For each base condition and alternative, the flow value was divided by the NSM value to obtain wet season and dry season proportions, which were then scaled. Scaling, using the normalized curve formulas described below, was used to obtain values between 0.0 and 1.0. In cases where the proportion of wet season flows exceeded NSM, they received a value of 1.0. For dry season flows, excess flows were treated the same as insufficient flows. For example, for the Cypress Group:

> IF (wet season flows >= NSM volumes, then Index = 1.0, else EXP(-((wet season flow – NSM)/NSM)^2/(2w^2))), where w = 0.5 gave the most reasonable values.

> IF (dry season flows = NSM volumes, then Index = 1.0, else EXP(-((dry season flow – NSM)/NSM)^2/(2w^2))), where w = 0.5 gave the most reasonable values.

Then, the wet season and dry season indices were averaged with the dry season weighted twice as heavily:

> Index(T7) = CIV(wet) 8 2(CIV(dry))

The overall Central Everglades Score, therefore, was:

> Score = (Index(T7) * Index(T8) * Index(T9) /3

Results

Improvements were seen over the 2050 Base in the Big Cypress Group (CYP) in all alternatives. Improvements in C and D over Alternative B echo the results seen by the Cypress subteam. The Central Everglades (CEver) transect groups were best served by the 1995 Base, but all alternatives were better than the 2050 Base. The Southern Everglades (SEver) transect groups received the highest score in Alternative A, but alternatives B, C and D were also very good with scores of 0.9. The Tamiami Trail Group (TT), comprising both east and west portions, also faired best with Alternative A, with good scores in alternatives B, C, and D. L-67 varied from a score of 0.0 in the 2050 Base to a moderate top score of 0.6 in Alternative B. Overall, all the alternatives scored higher than the 2050 Base and, when averaged, over the 1995 Base. Alternative A, which contained no decompartmentalization effort, received some of the highest scores, in the Southern Everglades and Tamiami Trail. The Big Cypress score was improved slightly with the reinstallation of L-28.

In D13R, where L-28 was removed again, the effects on flow volumes in Big Cypress were small and consisted of lower volumes in T25 (Eastern Big Cypress) and higher volumes in T26 (Lostman's Slough). Flow volumes across transects looked better in D13R than the 2050 Base. Flows across Tamiami Trail not only increased 92% over 2050 Base but the proportion flowing east of the L-67 vs. west of L-67 improved from only 11% in 2050 Base to 55% in D13R. NSM's east/west proportion was 62%. Flows through southern WCA-3A increased from only 62% of NSM volumes in the 2050 Base to 110% of NSM in D13R without causing excessive high water events. Flows in western WCA-3A were spread more evenly into the dry season in D13R, preventing the premature dry season drydowns seen in the 2050 Base.

**Sheetflow: Flow Volumes Across Transect Groups.**

| | 95 | 50 | A | B | C | D | D13R |
|---|---|---|---|---|---|---|---|
| CYP | 0.8 | 0.3 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 |
| CEver | 0.8 | 0.3 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| SEver | 0.8 | 0.3 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 |
| TT | 0.6 | 0.2 | 1.0 | 0.8 | 0.8 | 0.8 | 0.9 |
| L-67 | 0.1 | 0.0 | 0.1 | 0.6 | 0.1 | 0.1 | 0.1 |
| AVE | 0.6 | 0.2 | 0.7 | 0.8 | 0.7 | 0.7 | 0.7 |
| Color | - | Red | Green | Green | Green | Green | Green |
| Grade | - | F | B | B | B | B | B |
| Rank | - | 5 | 1 | 2 | 3.5 | 3.5 | - |

**Fragmentation: Miles of Canals and Levees**

Justification

In its effort to control floodwaters and provide water supply, the C&SF Project created miles of canals, levees, and water control structures with associated deep pools. Canals and levees usually coexist; construction of a canal usually means a spoil levee exists alongside it just as a levee requires a borrow canal. Roadway construction usually involves combinations of levees and canals, sometimes with culverts to allow water to flow underneath. Water control structures are usually even more complex, involving combinations of levees, canals and deep pools. In some places, multiple canals, levees and water control structures form intricate patterns - and formidable barriers to wildlife.

When levees block the flow of water, they also restrict the movement of aquatic and semi-aquatic life forms in the water. Land-based predators use the levees to invade the marsh interior, preying upon animals that try to cross the intrusive fingers of terrestrial habitat. Levees also act as conduits, allowing terrestrial plants to invade. Canals act as corridors particularly for non-native animals and plants that can extend their ranges rapidly from points of introduction and can move into wetlands where they can alter habitats and affect food webs (Loftus and Kushlan 1987; Loftus 1986). Artificial, deep-water habitats provide thermal and spatial refuge to large numbers of both non-native and native aquatic predators in the dry season, enhancing their survival and ultimate population sizes. During the dry season, these predators prey heavily on small marsh fishes and invertebrates moving in from the adjacent wetlands (Howard et al. 1995).

Performance Measure
1. Miles of Canals and Levees

Strategy for Developing Index

Using the numbers of miles canals and levees posted for the 1995 Base and the 2050 Base, the larger was considered to be the worst case scenario, the 100% build-out value. For each alternative and base condition, the number of miles of canals and levees were each divided by the maximum value and scaled using the following formula. For example, the index for canals for Alternative A was calculated as follows:

> Canals(A) = exp ((x-x*)/x*)^2(2w^2)-1), where w = -2.773, x = # of miles or levees for Alternative A, x* = the worst cast value.

Then, for each alternative and base condition, the canal and levee index scores were combined, canals receiving a weighting of two:

$$\text{Fragmentation Score} = (\text{Canals}_{alt} * \text{Canals}_{alt} * \text{Levees}_{alt})/3$$

The number of structures was available but the AET decided not to use these data in this analysis. The analysis would have been confusing because the weirs added to alternatives C and D were treated as additional structures, nullifying the beneficial effects of the weirs.

Results

Alternative A provided no benefits over the 2050 Base because it did not remove any canals or levees. Alternatives B, C, and D reduced the numbers of canals and levees substantially. Alternative B performed the best with 184 miles of canals and 318 miles of levees, 19 and 26 miles respectively fewer than Alternative D. Still, Alternative D had 127 fewer miles of canals and 56 fewer miles of levees than the 2050 Base.

In Alternative D13R, the number of miles of canals and levees fragmenting the remaining natural system was reduced even further to Alternative B amounts. Miles of canals were reduced by 40% and levees by 20% over the 2050 Base.

**Fragmentation: Miles of Canals and Levees**

| | 95 | 50 | A | B | C | D | D13R |
|---|---|---|---|---|---|---|---|
| Canals | 0.0 | 0.1 | 0.0 | 0.8 | 0.9 | 0.9 | 1.0 |
| Levees | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 | 0.7 | 0.5 |
| AVE | 0.0 | 0.1 | 0.0 | 0.8 | 0.7 | 0.7 | 0.8 |
| Color | - | Red | Red | Green | Green | Green | Green |
| Grade | - | F | F | A | B | B | A |
| Rank | - | 4.5 | 4.5 | 1 | 2.5 | 2.5 | - |

## B. Lake Okeechobee Subregion

### Lake Okeechobee Priority Hydrologic Performance Measures

Five priority performance measures are calculated, weighted and summed using the River of Grass Evaluation Model (ROGEM) for Lake Okeechobee. The Lake Okeechobee ROGEM is comprised of metrics (Suitability Index Variables, or SIVs) that concern the fluctuation and timing of lake stages. These variables exert major controls over ecosystem structure and function. Fluctuation and timing of lake stages affect the distribution of native and exotic plant communities, and in turn the habitat quality (cover, nesting sites, foraging habitat) for fish, birds, and other wildlife (Aumen 1995). The ROGEM assumes that restoration of a more natural (within the constraints of the dike system) hydroperiod would result in positive biotic responses of the lake community.

Each SIV ranges from 0 (worst score) to 1.0 (best score). Relationships between hydrologic attributes and SIVs in this model are not linear, but reflect expert opinion that the degree of ecosystem stress is exacerbated by an increasing occurrence of undesirable events. This gives rise to a curvilinear relationship between hydrologic attributes and their SIVs. At a certain point (considered here to be four events or more per decade), the degree of stress is so severe that the ecosystem cannot recover its ecological and societal values.

I. An <u>extreme low lake stage</u> (<11 ft) performance measure (**$SIV_{MINX}$**) indicates the frequency of events that result in a loss of over 95% of the littoral zone as habitat for aquatic biota, and promote expansion of exotic plants into pristine native-plant dominated regions of the lake. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never falls below 11 ft = 1.0
- Lake stage falls below 11 ft on 1 occasion per 10 yrs = 0.9
- Lake stage falls below 11 ft on 2 occasions per 10 yrs = 0.7
- Lake stage falls below 11 ft on 3 occasions per 10 yrs = 0.4
- Lake stage falls below 11 ft on 4 or more occasions per 10 yrs = 0

II. A <u>moderate low lake stage</u> (<12 ft) performance measure (**$SIV_{MINM}$**) indicates the frequency of prolonged (>12 continuous month) events that substantially reduce the littoral area available as wildlife habitat, and promote exotic plant expansion. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never falls below the 12 ft / 12 month criterion = 1.0
- Lake stage falls below the 12 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
- Lake stage falls below the 12 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7

- Lake stage falls below the 12 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
- Lake stage falls below the 12 ft / 12 month criterion on 4 or more occasions per 10 yrs = 0

III. An extreme high lake stage (>17 ft) performance measure (**$SIV_{MAXX}$**) indicates the frequency of events that may cause wind and wave damage to the shoreline plant communities, and transport phosphorus-laden pelagic water into pristine interior regions of the littoral zone. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never exceeds 17 ft = 1.0
- Lake stage exceeds 17 ft on 1 occasion per 10 yrs = 0.9
- Lake stage exceeds 17 ft on 2 occasions per 10 yrs = 0.7
- Lake stage exceeds 17 ft on 3 occasions per 10 yrs = 0.4
- Lake stage exceeds 17 ft on 4 occasions per 10 yrs = 0

IV. A moderate high lake stage (>15 ft) performance measure (**$SIV_{MAXM}$**) indicates the frequency of prolonged (>12 continuous months) events that may: limit light penetration to the lake bottom, resulting in a loss of the benthic plants and algae that stabilize sediments and provide habitat for invertebrates and fish; and promote greater circulation of phosphorus-rich turbid waters from mid-lake to less eutrophic near-littoral regions, where phosphorus inputs stimulate algal blooms. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never exceeds the 15 ft / 12 month criterion = 1.0
- Lake stage exceeds the 15 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
- Lake stage exceeds the 15 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7
- Lake stage exceeds the 15 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
- Lake stage exceeds the 15 ft / 12 month criterion on 4 occasions per 10 yrs = 0

V. A spring recession performance measure (**$SIV_{VAR}$**) indicates the number of years during which January to May lake levels decline from near 15 ft to 12 ft, without any reversals greater than 0.5 ft. These conditions appear to be favorable to nesting birds and other wildlife in the marsh. They also may allow for re-invigoration of willow stands, and permit fires to burn away cattail thatch. The goal is to have a substantial number of events. The performance measure score is calculated as follows:

- Stage recession between January and March from ~15 ft to ~12 ft NGVD, with no reversal greater than 0.5 ft NGVD, occurring every yr = 1.0
- Stage recession occurring , on average, every other yrs = 0.9
- Stage recession occurring, on average, once every three yrs = 0.7

- Stage recession occurring, on average, once every four yrs = 0.4
- Stage recession occurring less frequently than the above = 0

**SIV Priority Weights**

The five SIVs address important aspects of how water level and its seasonal variation affects the intrinsic ecological (e.g. habitat for wading birds and federally endangered species) and societal (e.g. recreational fisheries) values of Lake Okeechobee. However, the five SIVs are not considered of equal importance in regard to indicating an absolute level of stress (or benefit). A weighting scheme was developed, on the basis of best professional judgement, to reflect the relative importance of each SIV as an index of lake ecosystem health. For simplicity, a weighting scale of 1 to 5 (1 being least important, and 5 being most important) is used.

The SIVs associated with the >17 ft and >15 ft / 12 month criteria are given priority weights of 5. Extreme or prolonged high water levels have been documented to affect numerous ecosystem attributes, including: littoral plant and periphyton communities; benthic plants and periphyton; fisheries habitat; and water quality (including turbidity, phosphorus, and algal blooms). These effects are well documented by scientific research (Sheng and Lee 1991, Havens 1997, Steinman et al. 1997).

The SIVs associated with the <11 ft and <12 ft / 12 month criteria are given priority weights of 4. Extreme or prolonged low lake stages also may cause harm to the ecosystem, but the impacts are less documented, and are not considered as serious on a lake-wide basis. That is, the effects primarily are restricted to the littoral zone proper, and negative impacts (e.g., loss of fisheries habitat) may in part be compensated for by enhanced growth of submerged plants in the southern near-shore pelagic region.

The SIV for spring lake level recession describes a seasonally-variable hydro-pattern that is considered by experts to benefit a variety of littoral zone values, including wading birds and certain native plant communities (Smith et al. 1995). It is the only SIV that relates to seasonal variation in lake levels, and that variation is considered by experts (Havens and Rosen 1997) to be critical for a healthy ecosystem. However, there is a high degree of uncertainty in scoring the spring recession attribute. For example, do recession events that occur slightly earlier or later than the designated optimal (January-May) period have equal or lesser benefit to the community? Do recession events that occur over higher or lower ranges of water depth than the designated optimum (15 to 12 ft) have equal or lesser benefit to the community? There are no clear answers to these questions, and therefore, until further research results are available, the SIV associated with this attribute is given a weighting of 3.

**Integrated Scoring**

A Community Suitability Index (CSI) integrates the scores of five hydrologic SIVs and their respective weighting factors, and has an overall range of 0 to 1.0. The weighted CSI model is:

$$\textbf{CSI} = (4*SIV_{MINX} + 4*SIV_{MINM} + 5*SIV_{MAXX} + 5*SIV_{MAXM} + 3*SIV_{VAR}) / 21$$

From the standpoint of Lake Okeechobee ecological values, Alternative D13R performs in an identical manner to Alternative D, and is considered beneficial to the lake ecosystem.

Evaluation of Alternatives A-D, D13R and the revised 1995 and 2050 base conditions using Lake Okeechobee priority hydrologic performance measures, and ROGEM equations.

| **Variables** | **95Base** | **50Base** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** | **WGT** |
|---|---|---|---|---|---|---|---|---|
| | # Value | # Value | # Value | # Value | # Value | # Value | # Value | |
| **SIV min-x** | 3 | 4 | 2 | 2 | 1 | 1 | 1 | 4 |
| (Extreme Low Stage, <11') | 0.4 | 0 | 0.7 | 0.7 | 0.9 | 0.9 | 0.9 | |
| **SIV min-m** | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 4 |
| (Prolonged Low,< 12' for 12 mo.) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1 | 1 | |
| **SIV max-x** | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| (Extreme High Stage, > 17') | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | |
| **SIV max-m** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| (Mod.Stage, > 15' for 12 mo.) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | |
| **SIV var** | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 3 |
| (Spring Lake Level Recession) | 0 | 0 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | |
| **Weighted CSI** | **0.6** | **0.6** | **0.8** | **0.8** | **0.9** | **0.9** | **0.9** | |
| | | | | | | | | |
| | CSI = ((SIV min-x * 4) + (SIV min-m * 4) + (SIV max-x * 5) + (SIV max-m * 5) + (SIV var * 3)) / 21 | | | | | | | |

## C. Lake Okeechobee Service Area Subregion

### Procedure for Scoring Restudy Alternatives and Base Conditions for Water Supply

The Lake Okeechobee Service Area includes the Everglades Agricultural Area, the Caloosahatchee Basin, the St. Lucie Basin, the S-4 Basin, the L-8 Basin and the Seminole Indian (Brighton and Big Cypress) Reservations.

### Performance Measures and Indicators Used

Two performance measure reports are used to evaluate the frequency, duration and severity of water supply cutback events in the Lake Okeechobee Service Area. These are the detailed "LOSA Supply Side Management Report" and the "Frequency of Water Restrictions" graphic. Water restriction events vary as to how often they occur (frequency), how long an event lasts (duration), and how much of the water that would normally be demanded is not delivered (severity) and scores are developed for each of these characteristics.

### Scoring Procedures

The number of years with water restrictions from the "Frequency of Water Restrictions" graphic is the piece of information used to develop a score regarding the frequency of water shortages. The established performance target is that there be no more than 3 years during which cutbacks occur over the 30-year period of performance available from each simulation. This implies that all demands will be met in at least 27 years. The relevant period is 30 years because a crop/water service year from October to September is used in counting shortage events, instead of a calendar year. For example, in the 2050 base (revised) there are 14 years when all demands are met and 16 years with restrictions. In each case the score is developed as:

Score = (Number of Years When All Demands Are Met)/(Target years for All Demands Being Met) = (30 – Years With Restrictions)/27 with the limitation that the score is counted as "1" if the calculated score is greater than one.

The detailed "LOSA Supply Side Management Report" was used to develop a combined duration/severity score, for relative comparisons of alternatives only. The duration/severity scores apply only to months that are considered to have significant supply side management cutback volumes. For purposes of calculating the scores, months with less than 18,000 acre feet of supply side management cutback volumes are not considered significant and so are not included in the severity/duration scoring calculations. The duration portion of this score is the sum of the number of months with supply side management cutback volumes greater than 18,000 acre feet for each alternative. The severity portion considers the supply side management cutback volume in the worst month of each shortage event. The severity score given for each annual event is developed using the following table:

| The Largest Monthly Supply Side Management Cutback Volume (cut) of Each Event | Severity Score |
|---|---|
| 18,000 ac. ft. <=cut < 50,000 ac. ft. | 1 |
| 50,000 ac. ft. <=cut < 100,000 ac. ft. | 2 |
| 100,000 ac. ft. <=cut < 150,000 ac. ft. | 3 |
| cut >= 150,000 ac. ft. | 4 |

The total duration/severity score is the sum of the two scores. As an example, the duration/severity score for the revised 2050 Base is developed below

2050 Base Revised

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score (No. of Months with Supply Side Management Cutbacks > 18,000 ac.ft.) | Combined Duration Severity Score |
|---|---|---|---|---|
| 1968 | 130,570 | 3 | 3 | 6 |
| 1971 | 62,060 | 2 | 3 | 5 |
| 1972 | 73,380 | 2 | 2 | 4 |
| 1973 | 132,150 | 3 | 6 | 9 |
| 1974 | 154,730 | 4 | 6 | 10 |
| 1975 | 30,610 | 1 | 1 | 2 |
| 1976 | 135,190 | 3 | 5 | 8 |
| 1977 | 99,110 | 2 | 6 | 8 |
| 1978 | 52,360 | 2 | 1 | 3 |
| 1981 | 184,910 | 4 | 5 | 9 |
| 1982 | 104,460 | 3 | 9 | 12 |
| 1986 | 122,620 | 3 | 2 | 5 |
| 1989 | 143,530 | 3 | 7 | 10 |
| 1990 | 103,560 | 3 | 8 | 11 |
| 1991 | 70,060 | 2 | 5 | 7 |
| | | | **Total** | 109 |

Because it was desired to put the duration/severity scores on a 0 – 1 scale and because there was no target or allowable number of points, it was decided to make the scale relative to the poorest performing alternative. In this case it is the 2050 Base (revised). Thus the scores for all alternatives and base cases have been developed as:

> Scaled duration/severity score = 1 – (Combined Duration Severity Score for the alternative÷Combined Duration Severity Score for the Worst Alternative) = 1 – (Combined Duration Severity Score for the Alternative÷109)

**Aggregating Scores**

The final step in scoring the alternatives and bases in terms of water supply performance in the Lake Okeechobee Service Area is to aggregate the frequency and the duration/severity scores. This is accomplished by taking a weighted average of the two scores. In this case each of the scores was assigned an equal weight of 0.5, so the result is the simple average of the two scores.

**Summary and Interpretation of Water Supply Scoring Results**

This summarizes and interprets the scoring results achieved by applying the methodology set forth above. The results of the scoring are presented below in Table LOSA-1. Attachment LOSA-1 presents the calculations of the frequency scores and Attachment LOSA-2 presents the duration/severity scoring calculations contained in Table LOSA-1.

It is the opinion of the LOSA team that the resulting scores provide only an ordinal ranking of the alternatives. Differences or relative difference among the scores should not be interpreted as indicating a proportionate quantitative difference in performance. For this reason a ranking of the alternatives is provided in the rightmost column. A rank for the 2050 Base is provided because it could be selected as a "no action alternative". No rank is provided for the 1995 Base because it can not be selected as an alternative. It is interesting to note that the rank order of each of the components is the same. This implies that the rank orders of the combined scores will be the same no matter how the components are weighted.

**<u>Table LOSA-1 – LOSA Water Supply Scoring Results</u>**

| Base or Alternative | Frequency Score | Duration/ Severity Score | Combined Score | Rank |
|---|---|---|---|---|
| 2050 Base (revised) (no action alternative) | 0.519 | 0.000 | 0.259 | 5 |
| 1995 Base (revised) | 0.704 | 0.431 | 0.567 | NA |
| Alternative A | 0.852 | 0.789 | 0.820 | 3 |
| Alternative B | 0.778 | 0.661 | 0.719 | 4 |
| Alternative C | 0.889 | 0.789 | 0.839 | 2 |
| Alternative D | 0.926 | 0.853 | 0.890 | 1 |

While the scoring procedure provides a ranking of the alternatives, information from the performance measures and performance indicators can be utilized to provide a qualitative interpretation of the performance of the alternatives relative to the goals and relative to each other. The principal goal utilized by the LOSA subteam was that the alternatives should be able to meet all demands in a 1-in-10 year drought. It was also agreed that the best available indicator that this was being done would be if the number of years with water shortage restrictions were not more than three in the 31-year simulation period. In developing the count of years with water restrictions, certain events with very minor restrictions were not counted. None of the alternatives reach this goal (three or less events) but several come close. Alternative D has five events, Alternative C has six events and Alternative A has seven events. By comparison Alternative B has nine events and the 2050 Base 15 events.

Inspection of the events in alternatives A, C and D indicates that some of the events do not involve very many months with supply side management cutbacks and some of the months have relatively small volumes of cutbacks. As part of the effort to produce a duration/severity score, a slightly more restrictive definition of the amount of supply side management cutbacks that were required before it was significant enough to be counted was used. Under this criterion, months with monthly supply side management cutbacks of less than 18,000 acre feet are not counted and the numbers of water years with restrictions become three for Alternative D and five for Alternative C and Alternative A. By contrast Alternative B remains at nine events and the 2050 Base remains at 15 events under the revised criterion.

The strong performance of alternatives A, C and D is further evidenced when the duration (total months of supply side management with restrictions greater than 18,000 acre feet) of the water restriction periods is considered. For Alternative D, LOSA is under restrictions only nine months in the 31-year simulation period. For Alternatives A and C the restrictions are 13 months. By contrast, for Alternative B the restrictions are 21 months and for the 2050 Base they are 69 months.

In summary, alternatives A, C and D are considered to come close to meeting the water supply level of service goal and are judged to have good performance, with Alternative D being clearly the best performer. Alternative B has significantly poorer performance than alternatives A, C and D. The performance of the 2050 Base, the no action alternative, is unacceptable.

**Results of Alternative D13R**

Modifications to Alternative D that resulted in the revised Alternative – D13R had no significant effect on the good performance of Alternative D with respect to Lake Okeechobee Service Area water supply. This is shown in Table LOSA-2 below. With only five years with shortages, the frequency score is the same. The duration/severity score for D13R is slightly better because there is one less month of category 1 supply side management cutbacks (see Attachment LOSA-2).

**Table LOSA-2 – LOSA Water Supply Scoring Results Comparison of Alternative D and Alternative D13R**

| Base or Alternative | Frequency Score | Duration/ Severity Score | Combined Score |
|---|---|---|---|
| Alternative D | 0.926 | 0.853 | 0.890 |
| Alternative D13R | 0.926 | 0.862 | 0.894 |

**Attachment LOSA-1**

**Calculation of Frequency Scores**

| Alternative | Number of Water Years with Restrictions | Frequency Score = (30 – Years with Restrictions)/27 |
|---|---|---|
| 2050 Base (Revised) | 16 | 0.519 |
| 1995 Base (Revised) | 11 | 0.704 |
| Alternative A | 7 | 0.852 |
| Alternative B | 9 | 0.778 |
| Alternative C | 6 | 0.889 |
| Alternative D | 5 | 0.926 |

**Attachment LOSA-2**

**Calculation of Duration/Severity Scores**

Note that the scaled duration/severity score is calculated using the following formula: Scaled duration/severity score = 1 – (Combined Duration Severity Score for the Alternative ÷ Combined Duration Severity Score for the Worst Alternative) = 1 – (Combined Duration Severity Score for the Alternative÷109).

2050 Base (Revised)

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score (No. of Months with Supply Side Management Cutbacks > 18,000 ac.ft.) | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1968 | 130,570 | 3 | 3 | 6 |
| 1971 | 62,060 | 2 | 3 | 5 |
| 1972 | 73,380 | 2 | 2 | 4 |
| 1973 | 132,150 | 3 | 6 | 9 |
| 1974 | 154,730 | 4 | 6 | 10 |
| 1975 | 30,610 | 1 | 1 | 2 |
| 1976 | 135,190 | 3 | 5 | 8 |
| 1977 | 99,110 | 2 | 6 | 8 |
| 1978 | 52,360 | 2 | 1 | 3 |
| 1981 | 184,910 | 4 | 5 | 9 |
| 1982 | 104,460 | 3 | 9 | 12 |
| 1986 | 122,620 | 3 | 2 | 5 |
| 1989 | 143,530 | 3 | 7 | 10 |
| 1990 | 103,560 | 3 | 8 | 11 |
| 1991 | 70,060 | 2 | 5 | 7 |
| Total Combined Duration/Severity Score | | | | 109 |
| Scaled Duration/Severity Score | | | | 0.0 |

1995 Base (Revised)

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score (No. of Months with Supply Side Management Cutbacks > 18,000 ac.ft.) | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1968 | 34,560 | 1 | 1 | 2 |

| | | | | |
|---|---|---|---|---|
| 1971 | 26,580 | 1 | 1 | 2 |
| 1972 | 52,290 | 2 | 2 | 4 |
| 1973 | 113,750 | 3 | 6 | 9 |
| 1974 | 158,930 | 4 | 5 | 9 |
| 1978 | 48,520 | 1 | 1 | 2 |
| 1981 | 187,690 | 4 | 5 | 9 |
| 1982 | 103,030 | 3 | 8 | 11 |
| 1990 | 88,080 | 2 | 8 | 10 |
| 1991 | 39,010 | 1 | 3 | 4 |
| Total Combined Duration/Severity Score | | | | 62 |
| Scaled Duration/Severity Score | | | | .431 |

Alternative A

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1976 | 47,010 | 1 | 1 | 2 |
| 1978 | 23,610 | 1 | 1 | 2 |
| 1981 | 167,750 | 4 | 4 | 8 |
| 1982 | 94,320 | 2 | 3 | 5 |
| 1990 | 87,480 | 2 | 4 | 6 |
| Total Combined Duration/Severity Score | | | | 23 |
| Scaled Duration/Severity Score | | | | .789 |

Alternative B

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1974 | 84,660 | 2 | 1 | 3 |
| 1976 | 94,470 | 2 | 4 | 6 |
| 1977 | 35,920 | 1 | 1 | 2 |

| | | | | |
|---|---|---|---|---|
| 1978 | 23,600 | 1 | 1 | 2 |
| 1981 | 169,170 | 4 | 5 | 9 |
| 1982 | 96,890 | 2 | 3 | 5 |
| 1989 | 32,000 | 1 | 1 | 2 |
| 1990 | 93,950 | 2 | 4 | 6 |
| 1991 | 21,810 | 1 | 1 | 2 |
| Total Combined Duration/Severity Score | | | | 37 |
| Scaled Duration/Severity Score | | | | .661 |

Alternative C

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1974 | 21,560 | 1 | 1 | 2 |
| 1978 | 22,470 | 1 | 1 | 2 |
| 1981 | 168,680 | 4 | 4 | 8 |
| 1982 | 96,730 | 2 | 3 | 5 |
| 1990 | 76,880 | 2 | 4 | 6 |
| Total Combined Duration/Severity Score | | | | 23 |
| Scaled Duration/Severity Score | | | | .789 |

Alternative D

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1981 | 168,350 | 4 | 4 | 8 |
| 1982 | 95,040 | 2 | 3 | 5 |
| 1990 | 39,820 | 1 | 2 | 3 |

| | | | | |
|---|---|---|---|---|
| Total Combined Duration/Severity Score | | | | 16 |
| Scaled Duration/Severity Score | | | | .853 |

Alternative D13R

| Water Years With SSM Cutbacks | Highest Monthly Cutback | Severity Score | Duration Score | Combined Duration/ Severity Score = Severity Score + Duration Score |
|---|---|---|---|---|
| 1981 | 167,720 | 4 | 4 | 8 |
| 1982 | 95,140 | 2 | 3 | 5 |
| 1990 | 39,680 | 1 | 1 | 2 |
| Total Combined Duration/Severity Score | | | | 15 |
| Scaled Duration/Severity Score | | | | .862 |

## D. Lower East Coast Service Area Subregion

### Procedure and Scores of Alternatives and Base Conditions

Location

The Lower East Coast Service Area (LECSA) is divided into four service areas: North Palm Beach, and Service Areas 1, 2, and 3. The North Palm Beach Service Area extends from northern to central Palm Beach County, encompassing approximately one-third of the county and includes one primary canal, the C-17. Service Area 1 covers the remainder of Palm Beach County and a small portion of Broward County to just below the Hillsboro Canal. There are four primary canals that traverse the service area: C-51, C-16, C-12, and the Hillsboro Canal. Service Area 2 includes most of Broward County and a portion of Miami-Dade County. It extends south from the Hillsboro Basin to just south of the C-9, which lies in Miami-Dade County. Four primary coastal canals extend through Service Area 2: C-14, C-13, North New River, and C-9. Service Area 3 includes the remainder of Miami-Dade County from the C-9 Basin south to near the tip of the peninsula. There are three primary coastal canals in Service Area 3: C-4, C-6 and C-2. Although the county boundaries extend west to the center of the state, the service areas only include those portions of the counties east of the protective levees.

Background: Water Supply

The performance measures used for the Lower East Coast to evaluate Restudy alternatives for water supply relate to the frequency and duration of water supply cutback events and the ability to maintain primary coastal canals. Water supply cutbacks are mandatory reductions imposed by the District on the LECSA utilities and general population to conserve existing water supplies when a shortage is imminent. Water supply cutback events usually occur during the dry season, when replenishment of stored water is limited.

During the dry season structural releases are periodically made from the Water Conservation Areas (WCAs) and Lake Okeechobee to maintain ground water levels and to minimize the possibility of saltwater intrusion along the coast. The Lower East Coast uses this water from the regional system to recharge secondary canal networks, wellfields and other recharge areas, and lakes. These ancillary systems are maintained by the local utilities to continue meeting public water supply demands. During the wet season and under normal conditions, rainfall and seepage account for the vast majority of recharge to the LECSA surface and ground water system that supplies this area.

During extended dry periods, Lake Okeechobee and the WCAs are important sources of surface water supply for large regions of South Florida. WCAs 1, 2A and 3A are the primary sources of supplemental surface water supply for the Lower East Coast Service Areas 1, 2, and 3, respectively. When water stored in the WCAs and Lake Okeechobee is scarce, for instance during a drought, the urban water supply demands are restricted (cut back) in order to conserve the remaining supplies in the regional system. Although the service areas are able to continue to meet some demands through local sources, all service areas are dependent on the WCAs and Lake Okeechobee to supplement surface water supply and support urban public water supply demands. This is true for all of the service areas except Northern Palm Beach Service Area, which relies on local supplies.

The availability of recharge water to the LECSA via surface or ground water through either seepage or structural flows from the regional system can be evaluated based on the surface water storage in Lake Okeechobee. The storage volume within the lake gives a more quantitative indicator that a water shortage condition may be approaching. The water supply cutbacks in the LECSA are based partly on the available surface water storage in Lake Okeechobee. However, the primary triggering mechanism for implementing the LECSA cutbacks is related to ground water levels within the LECSA.

Low ground water levels near the coast increase the vulnerability of the Biscayne aquifer to saltwater intrusion. Continuing to meet urban water demands may exacerbate ground water levels and therefore cutbacks are necessary when there is a threat to the resource. Low storage levels in the Lake Okeechobee at the beginning of the dry season are indicative of a prolonged storage problem that dictates when the cutbacks can be removed while low ground water levels indicate immediate problems within the LECSA. Either of these triggers, Lake Okeechobee or local ground water levels, can initiate a water supply cutback and are reflected in the ability to meet the 1-in-10 level of service water supply goal. Although regional water supplies or local ground water levels may rebound during the dry season, cutbacks are continued through the end of the dry season, May, to ensure protection of the Biscayne aquifer.

The availability of water from the regional system to recharge the LECSA via structural discharges can be evaluated based on the ability to maintain the primary coastal canals above their saltwater intrusion criteria. This third performance measure, maintaining the surface water levels and continuing their recharge functions, is critical to protecting the Biscayne aquifer from saltwater intrusion. However, it should be noted that saltwater intrusion could still occur even if the primary canals are maintained. Some areas along the salt front cannot be adequately recharged from the regional system to offset local demands on ground and surface waters or to abate saltwater intrusion. Local conditions and demands can contribute to the movement of the salt front as well by lowering ground water levels.

The primary coastal canal performance measure is indicative of the ability to meet the proposed criteria for minimum flows and levels for the Biscayne aquifer. Chapter 373, F.S. directs all of the water management districts to establish minimum flows and levels for surface waters and aquifers within their jurisdiction. The District will be proceeding with rule development for the minimum level criteria for the Biscayne aquifer in the near future. The minimum level criteria for the Biscayne aquifer was utilized in the SFWMM model to reflect future demands from the regional system.

The performance measures described herein rely upon a linear relationship between performance and the scores developed for comparative purposes. Only the 1-in-10 level of service performance measure was normalized. No weighting was applied to the performance measures since all were considered equally important to continue the functions of the Biscayne aquifer and other resources in the Lower East Coast.

**Performance Measures and Indicators**

Two performance measures and one performance indicator are analyzed for each service area. In Service Area 3, an additional performance indicator, Ability to maintain South Miami-Dade Canals, was analyzed. These performance measures were selected due to their ability to measure how the alternative performs in protecting the Biscayne aquifer and providing recharge to the aquifer for public water supply. These measures are indicative of how well the conceptual designs may perform together on a regional scale. Additional feasibility studies and detailed designs will need to be pursued prior to implementation of any of the components included in the Comprehensive Plan.

1) **Ability to meet the 1-in-10 water supply planning goal:** The frequency of water supply cutbacks is indicative of the reliability of regional and local water supplies through various weather and resource conditions. Water supplies in Lake Okeechobee supplement deliveries to the LECSA to maintain ground water levels to prevent saltwater intrusion near the coast. Public water supplies are reduced or cutback at the well field in response to low surface water levels in Lake Okeechobee or ground water levels near the coast. The planning goal is to find a balance between ability of the regional system to supplement recharge of the aquifer and meet the public water supply planning goal of a 1-in-10 year level of service in the lower east coast of Florida. The planning goal is in terms of the frequency of cutback events and is defined as no more than three cutback events, no more than seven months in duration over the period of record. A cutback event can begin in the fall and continue through the spring, therefore the maximum number of cutback events in the period of record is thirty. The score represents the number of cutback events during the period of record minus the three allowed events compared to the maximum number of years the 1-in-10 year level of service planning goal can be met. Alternatives that equaled or exceeded the goal, i.e. had three or less cutback events, scored 100% (no extra credit was given for exceeding the planning goal).

Score =[1 ? ((# of cutback events ? 3 years)/27 years)]100 = % of years goal met

2) **Percentage of months not in a water supply cutback:** The duration of water supply cutbacks is another characteristic of a drought event and is used as an indicator of the reliability of water supplies. The number of months of water supply cutbacks incurred in a service area

capture the lengths of time urban demands are not met. The increased or decreased length of the cutback events is captured by counting the total number of months when the service area is in a water supply cutback, regardless of the severity of the cutback, as a percentage of the total number of months in the period of record. This percentage of time would be subtracted from one to reflect the improvement, increasing amount of time not in a water supply cutback, attributable to the alternative.

Score =[1? ((# of months service area in cutback)/372 months)]100 = % of time in a cutback

3) **Ability to maintain saltwater intrusion criteria:** Maintaining the primary coastal canals above the saltwater intrusion criteria is critical to protecting the Biscayne aquifer from saltwater intrusion and is part of the proposed criteria for minimum flows and levels. Each Service Area includes several primary coastal canals that have saltwater intrusion criteria developed for them. In the SFWMM, the stage of the coastal canal is compared to the criteria on a daily basis. If the canal is unable to be maintained for a week, the event is counted towards the time the saltwater intrusion criteria was not met. All canals were weighted equally except in Service Area 3, where the C-6 and C-2 were weighted more than the C-4 due to their ability to provide wellfield recharge. The performance measure is reported as the percentage of time the canal stage is below the saltwater intrusion criterion, which is subtracted from one to report the percentage of time the canal is above the saltwater intrusion criterion.

Score = [1- % of time not able to maintain canals ]100 = % of time able to maintain canals

4) **Maintaining water levels in south Miami-Dade canals:** At this time, saltwater intrusion criteria do not exist for the major canals in southern Miami-Dade County. However, it is important to evaluate water levels in these canals because encroachment of the salt front into the Biscayne aquifer has occurred previously in this area. Plus, major public water supply wellfields are located in southern Miami-Dade County. This area was evaluated by using the stage duration curves for the following structures: C-100A @ S-123, C-1 @ S-21, C-102 @ S-21A, and C-103 @ S-20F. The stage duration curves were used to evaluate the alternatives in two ways: 1) the distance by which an alternative's water level fails to reach two feet NGVD at the 90th percentile of the stage duration curve; and 2) the percentile at which an alternative's stage duration curve meets the 50th percentile of the 1995 Base stage duration curve.

In the first scenario, two feet NGVD was used for comparison in keeping with the Ghyben-Herzberg relationship which estimates that one foot of fresh water head is required to protect 40 feet of aquifer. The aquifer along the coast in southern Miami-Dade is approximately 80 feet that would require two feet of fresh water head. The 90th percentile of the stage duration curve was used since that percentile reflects lower stages of the dry season when the risk of saltwater intrusion is increased. The score is calculated from the distance of the base conditions and alternatives to the two feet NGVD on the stage duration curve. Alternatives that equaled or exceeded the target scored 100% (no extra credit was given for exceeding the target).

Score = [(2 - Distance/2)] x 100 = % of meeting 2 foot target

The second scenario used the 50th percentile of the 1995 Base to evaluate performance since it represents approximately the midpoint between the wet and dry seasons and can be viewed as "average conditions" for the 1995 Base. The score reflects the percentile at which a base condition or alternative meets or exceeds the water level at the 50th percentile of the 1995 Base. Saltwater encroachment has occurred in the period of record and, therefore, exceeding the 50th percentile is considered an improvement but may not prevent further encroachment.

The base conditions and alternative scores were determined by averaging the scores for the two scenarios.

**Flood Protection**

Flood protection is one of the authorized purposes of the Restudy and will be evaluated and addressed during the detailed design phase of the study. Due to the grid size and type of model used during the Restudy alternative evaluation process, the performance measures available for the Lower East Coast Service Area are of limited value for direct evaluation of an alternative's affect upon flood protection. However, one performance indicator is applicable for the southern Miami-Dade County agricultural areas in Service Area 3, stage duration curves, and is used in this evaluation.

**Urban Areas East of the Protective Levee in the Lower East Coast**

Flood protection should be improved or at least not degraded by the selected plan. In many instances, the alternatives have reduced or eliminated adverse impacts to flood control associated with the components selected in the urban areas of the Lower East Coast. The alternatives provide additional water storage capacity through water preserve areas, reservoirs and aquifer storage and recovery, reducing the maximum stages in the canals during large rainfall events.

The risk of flooding may be decreased with the additional storage components; however, it is difficult to discern the improvements at this point in the alternative evaluation. The model used to evaluate the effects of the components on regional hydrology is not conducive for evaluating storm and flood events. The model uses a daily time step; storm and flood events occur within hours. One-performance indicator gauges the change in peak stages compared to the 1995 Base on a regional basis. The primary drawback of this performance indicator is that it does not distinguish between ground and surface water levels.

After the final plan is selected, this performance indicator will be used to identify areas of potential decreased flood protection coupled with site specific information regarding flood prone areas. Information regarding existing flood prone areas will be gathered from District and USACE staff familiar with the Lower East Coast supplemented with interviews with local government officials and other who have technical input. These areas will be mapped using the SFWMM grid cell boundaries and will be identified by the appropriate basin. These identified areas will undergo further evaluation in subsequent feasibility reports to determine what actions are necessary. In addition, portions of the study area outside of the boundaries of the SFWMM grid will need to be evaluated for flooding impacts through a separate process as well.

## Agricultural Area along the L-31N

### Performance Measure Used

One performance measure graphic was developed for use in six cells in the western areas of southern Miami-Dade County (Lower East Coast Service Area 3) to compare the relative performances of the different alternatives. It is labeled “end of the month stage duration curve 1983-1993”, and compares an 11-year target stage duration curve to the 31-year stage duration curves representing the performances of the bases and alternatives. The relative comparison of an 11-year curve to a 31-year curve appeared to be appropriate for use at the higher stages, but did not compare as well at the mid to lower stages.

### Scoring Procedures

Because the comparisons between the curves are most appropriate at the higher stages, it was decided to use the point where the stage duration curves intersect with the “10 % time equaled or exceeded” line on the graphs. For each of the six indicator cells, the difference between where an alternative or base curve intersects the 10 % line and where the target curve intersects the 10 % line is measured (in tenths of a foot).

Only the increases in stages relative to the target are included in the matrix. The actual differences are shown in the first half of the matrix, and are used in the alternative scoring methodology described below. If an alternative performance falls below the target (performance is better than the target), a score of 0 is given. This is shown in the second half of the matrix. The values for all the cells are summed and normalized so the final scores range between 0 and 1.

A second scoring methodology that gives credit for flood protection above the target was used for comparison. In order to normalize the alternatives’ scores, five (5) was added to each sum so the final numbers were all positive. The resulting values are shown as an “alternative score”.

### Interpretation of Results

Using the first scoring methodology, all of the alternatives performed equally. There is no measurable difference between the stage duration curves at the 10% line. The operational changes that were implemented in the C-111 basin in all alternatives are thought to be the reason for this result. The 1995 Base produces the best performance, and the 2050 Base the worst, indicating that some of the components associated with the Experimental Water Deliveries Program have the potential to impact the level of flood protection in this area of Miami-Dade County.

In looking at the second scoring methodology where credit is given for an increase in flood protection in some of the northern cells, alternatives B and C perform the best, followed (in order) by alternative A, D, 1995 Base, and the 2050 Base. Since exceedence of the target line is a “bonus”, and since it only occurred in some of the cells, it’s not recommended to base selection of a preferred alternative on these results. They are presented only for informational purposes.

Alternative D13R performed equally to Alternative D. There were no changes in operations in this area, so the performance did not change.

| | R10 C25 | R13 C25 | R15 C26 | R17 C27 | R19 C27 | R20 C27 | |
|---|---|---|---|---|---|---|---|
| | | | Difference in stage in tenths of a foot | | | | Totals |
| 95Base | 1 | 1 | 2 | -1 | 0 | 0 | 3 |
| 50Base | 5 | 7 | 6 | 1 | 1 | -2 | 18 |
| Alt A | 0 | 3 | 4 | -3 | -3 | -4 | -3 |
| Alt B | 0 | 3 | 4 | -3 | -3 | -5 | -4 |
| Alt C | 0 | 3 | 4 | -3 | -3 | -5 | -4 |
| Alt D | 0 | 3 | 4 | -3 | -2 | -3 | -1 |
| Alt D13R | 0 | 3 | 4 | -3 | -2 | -3 | -1 |
| | | | Increases in stage relative to the Target (tenths) | | | | |
| 95Base | 1 | 1 | 2 | 0 | 0 | 0 | 4 |
| 50Base | 5 | 7 | 6 | 1 | 1 | 0 | 20 |
| Alt A | 0 | 3 | 4 | 0 | 0 | 0 | 7 |
| Alt B | 0 | 3 | 4 | 0 | 0 | 0 | 7 |
| Alt C | 0 | 3 | 4 | 0 | 0 | 0 | 7 |
| Alt D | 0 | 3 | 4 | 0 | 0 | 0 | 7 |
| Alt D13R | 0 | 3 | 4 | 0 | 0 | 0 | 7 |
| | | **SCORE** | | | **Alternative Score** | | |
| 95Base | | **0.9** | | | | **0.73** | |
| 50Base | | **0.3** | | | | **0.23** | |
| Alt A | | **0.8** | | | | **0.93** | |
| Alt B | | **0.8** | | | | **0.97** | |
| Alt C | | **0.8** | | | | **0.97** | |
| Alt D | | **0.8** | | | | **0.87** | |
| Alt D13R | | **0.8** | | | | **0.87** | |

**Other Issues**

**Isolated wetlands and other natural areas east of the protective levee:** Performance measures for isolated wetlands and natural areas east of the protective levee, although important pieces of the remnant Everglades, are not included in this performance matrix. Due to the scale of the SFWMM relative to isolated wetlands, the impact of components cannot be accurately depicted. The scale of the model prevents evaluating features that are smaller than the four square mile grid, with the exception of canals and control structures. In addition, the differences between the alternatives and their components' potential impacts to wetlands may be imperceptible. The influence of the components located primarily west of the levee on ground and surface water levels in areas that have been severed from the regional system by the protective levee is limited. Some of these natural areas are dependent on discharges from primary canals that may be affected by projects located upstream. In these cases, the potential effect of the alternatives can be evaluated to identify problems. Two control structures that supply water to the Pond Apple Slough and North Fork of the New River in Service Area 2, C-13@S-33 and C-11@S-13, experience fluctuations in discharge across the alternatives. During the detailed design phase or perhaps as part of an Other Project Element, the potential impact to these areas should be taken into consideration and minimized, and if possible, their discharges increased to meet their demands.

**Interpretation of Scores for LECSAs**

**Summary:** Based on the above interpretation of the performance measures, Alternatives C and D perform equally well and substantially improve water supplies compared to the 2050 Base for the Lower East Coast Service Area. Alternatives C and D are the preferred alternatives. Alternatives A and B also improve upon the 2050 Base, but do not perform as well as Alternatives C and D.

**North Palm Beach Service Area:** The North Palm Beach Service Area scores very well, almost reaching the established goals in all alternatives. The average score for the alternatives exceeds 96%, with Alternative D reaching 99%. The performance of the primary canals reaches their goals in all of the alternatives. The 1-in-10 level of service planning goal scores are very high in all alternatives, above 95%. The duration of cutbacks scores are very high as well and are just shy of reaching their goal. Compared to the 2050 Base, any of the proposed plans relying on alternative sources would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in the North Palm Beach Service Area.

**Service Area 1:** Service Area 1 performs very well almost reaching the established goals in all alternatives. The average score for the alternatives exceeds 96%, with Alternative D reaching 99%. The performance of the primary canals reaches their goals in all of the alternatives. The 1-in-10 level of service planning goal scores very high in all alternatives, above 95%. The duration of cutbacks scores are very high as well and are just shy of reaching their goal. Compared to the 2050 Base, any of the proposed plans relying on alternative sources would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in Service Area 1.

**Service Area 2:** Service Area 2 performs well in all of the alternatives, with C and D performing better than A and B. The average score for the alternatives exceeds 88%, with Alternative D reaching as high as 95%. This compares very favorably to the 2050 Base, which scores only 54% for Service Area 2. Alternatives C and D perform almost equally as well as each other as Alternative A performs similar to B. The ability to maintain primary coastal canals performed well in all of the alternatives; it is just shy of reaching its goal for the four alternatives. The 1-in-10 level of service planning goal score for all of the alternatives is significantly higher than the 2050 Base, which has cutbacks almost every year, scoring a dismal 4%. Alternatives C and D perform better than alternatives A and B on reducing the frequency of cutbacks. Although

Alternative C scores slightly lower than D, the actual difference is nine more months of cutbacks over the period of record in Alternative C. This is reflected in the duration performance measure. The duration of cutbacks scores improve significantly when compared to the 2050 Base. Compared to the 2050 Base, any of the proposed plans would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in Service Area 2. However, alternatives C and D perform better than either A or B and are preferable.

**Service Area 3:** In Service Area 3, the overall performance improves in all alternatives compared to the 2050 Base, with C and D performing better than A and B. Alternatives C and D perform almost equally as well as each other, as Alternative A performs similar to B. The average score for all of the alternatives exceeds 79%, with Alternative D reaching as high as 92%. This compares favorably to the 2050 Base, which scores only 70% for Service Area 3. All of the alternatives performed well in maintaining the primary coastal canals. The other canals in southern Miami-Dade County do not perform well in Alternatives A or B, showing little to no improvement compared to the 2050 Base. Alternatives C and D do score significantly better for maintaining these canals, but fail to perform well enough to reach their target. All of the alternatives' performance improves significantly over the 2050 Base in meeting the 1-in-10 level of service planning goal, with Alternative D performing the best. The duration of cutbacks scores very high for all alternatives, with Alternative D performing the best. The difference in duration between alternatives C and D is only five additional months of cutbacks over the 31-year period of record. Except for maintaining water levels in southern Miami-Dade canals, the performance of all of the alternatives as evaluated in the matrix exceeds the performance of the 2050 Base. However, alternatives C and D perform better than either A or B and are preferable.

**Comparison of Alternative D with Alternative D13R**

Alternative D13R performs essentially the same as Alternative D. The two alternatives are indistinguishable in their ability to meet public water demands, minimize the duration of cutbacks, and maintain saltwater intrusion stages in the primary coastal canals. It meets most of the performance measures for the Lower East Coast Service Area, greatly improving the ability to meet public water supply demands and prevent saltwater intrusion over the 2050 Base.

**Considerations**

The LEC subteam only considered the scores and their indication of an alternative's ability to meet performance measures when selecting a preferred plan. While the scores may reflect alternatives C and D perform better than alternatives A and B, many of the water supply components chosen for all the alternatives will require greater analysis to assure that they can be implemented. Because of the high-risk based nature of some of the key water supply features (ASR, seepage control, low-phosphorus reuse), plan selection is possible as general guidance only. However, selection of a plan may require selection of components from several of the alternatives, determination of the feasibility of the technologies included, and evaluation of the cost effectiveness of the components. The Implementation Plan should describe and address many of the specific concerns of the LEC subteam.

**Subregion: Lower East Coast Service Area***

| Performance Measure | 1995 Base | 2050 Base | Alt A | Alt B | Alt C | Alt D | Alt D13R |
|---|---|---|---|---|---|---|---|
| Ability to Meet 1-10 water supply planning goal for NPB SA | 70% | 56% | 95% | 95% | 100% | 100% | 100% |
| Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in NPB SA | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| % of Months Not in Water Supply Cutbacks in NPB SA | 87% | 81% | 93% | 93% | 95% | 96% | 96% |
| **North Palm Beach Service Area Average Score** | **86%** | **79%** | **96%** | **96%** | **98%** | **99%** | **99%** |
| Ability to Meet 1-10 water supply planning goal for SA 1 | 63% | 40% | 95% | 95% | 100% | 100% | 100% |
| Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 1 | 100% | 100% | 100% | 100% | 100% | 99% | 100% |
| % of Months Not in Water Supply Cutbacks in SA 1 | 87% | 76% | 93% | 93% | 95% | 96% | 96% |
| **Service Area 1 Average Score** | **83%** | **72%** | **96%** | **96%** | **98%** | **98%** | **99%** |
| Ability to Meet 1-10 water supply planning goal for SA 2 | 26% | 4% | 56% | 56% | 85% | 93% | 93% |
| Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 2 | 94% | 95% | 100% | 100% | 99% | 99% | 100% |
| % of Months Not in Water Supply Cutbacks in SA 2 | 75% | 62% | 88% | 87% | 92% | 95% | 95% |
| **Service Area 2 Average Score** | **65%** | **54%** | **81%** | **81%** | **92%** | **96%** | **96%** |
| Ability to Meet 1-10 water supply planning goal for SA 3 | 78% | 56% | 74% | 78% | 93% | 95% | 95% |
| Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 3 | 77% | 89% | 95% | 100% | 100% | 100% | 100% |
| Ability Maintain Water Levels in South Dade Canals** | 58% | 56% | 55% | 57% | 76% | 77% | 77% |
| % of Months Not in Water Supply Cutbacks in SA 3 | 89% | 79% | 90% | 91% | 94% | 95% | 95% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Service Area 3 Average Score** | **76%** | **70%** | **79%** | **82%** | **91%** | **92%** | **92%** |
| **Average Weighted Score** | **77%** | **69%** | **88%** | **89%** | **95%** | **96%** | **96%** |

* Flood protection not evaluated in this matrix

## E. Northern / Central Everglades Subregion

Evaluation Methodology

Performance Measures and Regions Evaluated

Model results for each alternative were evaluated at the level of individual Indicator Regions. Scores were then aggregated into spatially and hydrologically-distinct groups. Initially, evaluations were based on five performance measures, with each measure comprising one or two component variables. The performance measures and variables were:

1. Inundation pattern (variables: number and mean duration of inundation periods);
2. Extreme high water (variables: number and mean duration of high water events);
3. Extreme low events (variables: number and mean duration of low water events);
4. Interannual depth variation (variables: October and May between-year standard deviations); and
5. Average seasonal amplitude (variable: October mean depth minus May mean depth).

Performance measures 1-4 were approved by the AET early in the alternatives development process and had been used in prior evaluations of Alternatives 1-5. Performance measure 5 was added as a means to evaluate seasonal depth variation. After inspection of initial scores, however, use of measures 4 and 5 was discontinued, as it was found that performance for these measures was acceptable and varied little among the alternatives.

Target variable values for the performance measures were those predicted by NSM 4.5, Final, with four exceptions: (1) in Indicator Region 17, performance was evaluated by comparing values to the average of NSM values for Indicator Regions 14 and 18; this was because the NSM depths in this indicator region had been identified during evaluation of alternatives 1-3 as being lower than desirable for this relatively pristine marsh area; (2) in LNWR, the targets were 1995 Base values, in keeping with the refuge's current regulation schedule; (3) for high water extremes, the performance target was that the number and duration of events be less than or equal to NSM values; and (4) for low water extremes, the performance target was for frequencies and duration of events to be minimized.

During the first round of evaluations, the results for individual indicator regions were aggregated into three sub-areas: (1) Central Ridge and Slough (WCAs 2A, 2B, 3B, and most of 3A); (2) Sawgrass Plains (Holey Land, and Rotenberger WMAs plus NE WCA-3A); and (3) Loxahatchee NWR. However, because hydrologic performance of the alternatives did not fall clearly into these landscape-defined categories, the final evaluation classified the indicator regions into ten subregions that correspond areas with distinct hydrologic performance. These are:

1. Loxahatchee NWR (Indicator Regions 26 & 27)
2. Holey Land & Rotenberger WMAs (Indicator Regions 28 & 29)
3. WCA-2A (Indicator Regions 24 & 25)
4. WCA-2B (Indicator Region 23)
5. NW WCA-3A (N of Alligator Alley & W of Miami Canal; Indicator Regions 20 & 22)

6. Northeastern WCA-3A (N of Alligator Alley & E of Miami Canal; Indicator Region 21)
7. Eastern WCA-3A (S of Alligator Alley, E of Miami Canal; Indicator Region 19)
8. Central & Southern WCA-3A (S of A. Alley, W of Miami Canal; Indicator Regions 14, 17 & 18)
9. WCA-3B (Indicator Regions 15 & 16)
10. Pennsuco Wetlands (Indicator Regions 52 & 53)

Index Calculation Method

Index values were developed for each performance measure and indicator region in order to simplify comparison of the alternatives. The method for calculating these indices is described below. It is important to note that the indices are valid only for making relative comparisons among different models for a single performance measure averaged over at most a few similar indicator regions. In addition, the scale of the index values for each performance measure does not map directly to any ecological interpretation of restoration potential for the alternative; it is color and letter grade scores that are used for that purpose. Indices and ranks function strictly as a means of ordering the alternatives and base cases relative to each other on the basis of their ability to achieve planning targets.

Inundation Pattern

For inundation pattern, subscores for the two variables, number and mean duration of inundation events , were calculated using the formula:

$$\text{score} = \exp[-2.773(\text{Target value-Alternative value/Target value})^2] .$$

This describes a smooth curve that assigns a maximum score of 1.0 only when the value for the alternative exactly equals the target value, and assigns a score of 0.5 when the alternative's value is 50% larger or smaller than the target value. Values that deviate from the target by less than 50% are assigned scores greater than 0.5 that increase to 1.0 as the alternative's value approaches the target. Values that deviate from the target by more than 50% are assigned scores less than 0.5 that approach zero as the distance from the target value increases. The summary index for inundation pattern was calculated as the arithmetic average of the two subscores.

High Water Extremes

For high water extremes, subscores were calculated for number of high water events and mean duration of events. If the alternative's value for the variable was less than or equal to the NSM-defined target, then a score of 1.0 was assigned. If the alternative value exceeded the target, then the score was calculated using the formulae:

$$\text{score for \# events} = \exp[- (\text{Alternative \#events -Target \#events})^2/8)]; \text{ and}$$

$$\text{score for duration of events} = \exp[- (\text{Alternative duration-Target duration})^2/18)].$$

These formulae assign a score of 0.61 when the alternative value exceeds the target value by two events or by three weeks, respectively. Scores fall off toward zero as number and/or duration of events increases. The summary index for high water extremes was then calculated as the simple average of the two subscores.

Low Water Extremes

For low water extremes, scores were calculated for the two variables, number of low water events and mean duration of events, according to the formula:

$$\text{score} = \exp[-(\text{Alternative value})^2/2(\text{NSM value})^2)].$$

This assigns a score of 1.0 when the alternative's value equals zero, and a score of 0.61 when the alternative's value equals the NSM value. Scores between 0.61 and 1.0 identify performance that is "better" than NSM at reducing the number and/or duration of low water events, while scores of less than 0.61 approach zero as the number and/or duration of low water events gets large. As above, the summary index was calculated as the simple average of the two subscores.

Seasonal and Interannual Variability

Scores were assigned to seasonal amplitude, October standard deviation, and May standard deviation, using the same formula as that for inundation pattern. The summary index was then calculated as a weighted average:

Index = (0.5)(seasonal amplitude score) + (0.25)(Oct. st.dev. score+May st. dev. score).

As noted above, use of this index was discontinued after initial inspection of results, because alternatives generally performed well and did not differ appreciably. The few exceptions to this are described in the narrative evaluation below.

Combined Indices

Indices were aggregated in two ways: across performance measures within individual indicator regions; and across indicator regions within subregions. The individual indices and averages are listed in Tables Northern and Central Everglades – 1, 2 and 3 below.

(1) Spatial averages. For each performance measure, an average index value was obtained for each subregion, weighting each indicator region by the approximate spatial area of the landscape that it represented (defined by counting model grid cells in that region of the SFWMM). The weights assigned are listed in Table Northern and Central Everglades – 4 below.

(2) Overall performance average. For each indicator region, the three indices for inundation pattern, high water extremes, and low water extremes were averaged to obtain a summary score. This was a weighted average, with the index for inundation pattern given half the weight assigned to each of the other indices. This weighting was chosen in order to reduce the influence of the differences in inundation pattern indices on the overall average, on the rationale that an exact matching of NSM inundation values within an indicator region was not likely to be significantly better at promoting long-term sustainability of the marsh than was a pattern that was broadly consistent with NSM within that landscape region, but not necessarily a good match for the specific indicator region being scored.

Ranking of Alternatives

The indices were used as a basis for ranking Alternatives A-D relative to each other and the 2050 Base. For each performance measure and indicator region, indices were rounded to the nearest 0.1 and then ranked from 1 to 5, with ties given the mean of the tied ranks. These ranks were then averaged across indicator regions using the spatial weights described above, and were also averaged, without weighting, across the three performance measures. This analysis acted as a check for the results obtained with the index values, by creating an ordering of alternatives that was less subject to possible shifts in rank that can occur when non-linear functions are averaged. Ranks for Alternatives A-D and 2050 Base are presented in Table Northern and Central Everglades – 5.

Color and Letter Grade Assignment

The indices and ranks described above allowed alternatives to be compared to the base cases and to each other. However, because the numeric scale is largely arbitrary from a biological perspective, an ecological interpretation of the alternative cannot be deduced from the index scores. A separate evaluation method was done for this purpose. Each performance measure for each indicator region was evaluated using best professional judgment of subteam members as to the ecological consequences of the predicted performance. Values were compared not only to target values and to the 2050 Base, but also to the 1995 Base and to output for other indicator regions where helpful. The subteam then assigned each indicator region a "color" score of Green, Yellow, or Red for each performance measure, and used these to choose a summary color for the indicator region. The criteria for color assignment were as follows.

GREEN. Green was assigned if the model performance was thought to predict conditions expected to promote a sustainable Everglades marsh community. The primary indicators for this were:

(1) protection and accretion of peat soils indicated by a low predicted occurrence of extreme low water (depths more than 1.0 ft below ground surface);

(2) persistence of tree island communities indicated by a low predicted frequency of extreme high water; and

(3) an inundation pattern suitable for an Everglades sawgrass or ridge-and-slough marsh, as indicated by a number and mean duration of inundation events that either closely matched the target for that indicator region, or that fell within the range of patterns predicted by the NSM for that landscape type.

YELLOW. Yellow was assigned if the ecological consequences of the performance were considered uncertain. This uncertainty generally fell into one of two classes: (1) performance deficits that appeared to be "fixable" as part of detailed design or during optimization of operational rules; and (2) uncertainty that could only be resolved via biological monitoring and adaptive management during implementation, because the key issues concerned uncertain biological results of the predicted hydrologic changes. In either case, yellow identified areas where special caution appears to be necessary in implementing any project changes.

RED. Red was assigned if the performance was judged to predict conditions not expected to lead to a sustainable Everglades marsh. The primary criteria for this classification were:

(1) high predicted frequencies of extreme dry-outs that seemed certain promote continued peat loss; (2) high predicted frequencies of extreme high water that would be expected to eliminate tree-island vegetation communities and adversely affect animals that depend on them; and/or (3) inundation or depth patterns that fell well outside the range of conditions predicted by the NSM for that landscape type.

GRADES. Letter grades were assigned according to the following criteria:
Green areas: "A" or "B," depending on level of confidence in the restoration potential of the alternative;
Mixed Yellow/Green areas: grade of "B";
Yellow areas: "C" or "D," depending on degree and severity of uncertainty;
Mixed Yellow/Red areas: "D"; and
Red areas: "F."

## NORTHERN AND CENTRAL EVERGLADES SUBTEAM REPORT FOR ALTERNATIVES A-D AND D13R

### Evaluation/Interpretation of Alternatives A-D

The overall rankings, grades and colors assigned by the subteam to Alternatives A-D are listed together in Tables 1-3 of the Introduction to this report. The following text describes, for each subregion, the specific performance evaluation and interpretation that led to the subteam assignments of colors and letter grades. It also includes an interpretation of the overall performance of Alternatives A-D for the Northern and Central Everglades.

### Loxahatchee NWR (Indicator Regions 26 and 27)

Loxahatchee NWR performs well in all four Alternatives, matching targets defined by the 1995 Base. The number and mean duration of inundation events for Alternatives B-D are nearly identical to 1995 Base values, with a 99% overall hydroperiod in southern LNWR and a 95% hydroperiod in northern LNWR. This is an improvement over the drier conditions predicted for the 2050 Base (94% hydroperiod in south, 90% hydroperiod in north). Alternative A is slightly drier than the 1995 Base, especially in the north, where there are 20 inundation events averaging 76 weeks in duration, as opposed to 13 events averaging 199 weeks in 1995 Base.

The occurrence of extreme low water is reduced in all four Alternatives compared to the 2050 Base, with only one short-duration event in northern LNWR, as compared to the 2050 Base, which has five events averaging five weeks duration in the north, and two events averaging four weeks in the south. All four alternatives are close to the 1995 Base target of no more than one four week-long event in the north and zero events in the south.

All four alternatives also meet performance targets for extreme high water. High water events do not occur in the north, and, although common in the south part of the refuge, high water events are fewer and of shorter duration than in the 1995 Base. Overall, southern LNWR experiences depths greater than 2.5 feet for 24-25% of the simulation period, as compared to 20% of time in the 2050 Base and 30% in the 1995 Base. There is some uncertainty about the effect of high water on tree islands in southern LNWR. However, the alternatives conform overall to current hydrologic management objectives for the refuge.

**Holey Land and Rotenberger WMAs (Indicator Regions 28 and 29)**

Both Holey Land and Rotenberger WMAs perform nearly identically in all four alternatives. The regulation schedule assumed for Rotenberger WMA appears to eliminate high water extremes effectively while maintaining suitable NSM-like inundation patterns. In Holey Land, depths greater than 1.5 ft occur 6-8% of time, but depths greater than 1.75 ft occur only 1-2% of time. In both WMAs, the frequencies and durations of extreme low water are less than those predicted by NSM; however, drought conditions still occupy 3-4% of the simulation period. Although there is uncertainty about the minimum conditions needed to protect peat soils, so long as the alternative provides dry season deliveries via the STAs, it should be possible to adjust operational details so as to avoid further soil loss in these areas.

It should noted that in Holey Land WMA, differences in performance relative to the 1995 and 2050 Bases do not provide a realistic comparison with the alternatives, because the Bases assumed a 0-2' regulation schedule that is not currently in use, nor is it likely to be implemented in the future. Hence, the subteam evaluation in this area was restricted to comparisons with target values.

**WCA-2A (Indicator Regions 24 and 25)**

In general, Alternatives A-D exhibit problematic performance in WCA-2A, with uncertain results for southern WCA-2A (Indicator Region 24) and poor performance in northern WCA-2A (Indicator Region 25).

In southern WCA-2A, inundation patterns were very similar to NSM in all four alternatives, with Alternatives B, C, and D performing slightly better than Alternative A. However, in northern WCA-2A, inundation periods were of much longer duration, with less frequent dry-outs, than NSM target values. Here Alternative A performed somewhat better than Alternatives B, C, and D, which had only nine inundation events averaging 173 weeks duration, in contrast with the NSM target of 30 inundation events averaging 46 weeks duration. Hence, where NSM predicts that northern WCA-2A would have dried out approximately every year during pre-drainage times, Alternatives B-D predict dry-outs to occur less than once every three years, on average, while Alternative A predicts the marsh to dry out in roughly two years out of five. Northern WCA-2A was also one of the only regions in the WCA system that performed poorly for seasonal variability; all four Alternatives had annual amplitudes in depth between wet and dry seasons that were smaller than those predicted by the NSM, and the annual mean maximum depth occurred early in the wet season rather than later as predicted by NSM (see performance indicator "Temporal Variation in Mean Weekly Stage for Northern WCA-2A").

Although southern WCA-2A met NSM target values for inundation pattern, it experienced more extreme high water than either Base, as well as more extreme low water than might be desired for protection of peat soils. Although extreme high water occurred only 1% of time in

Alternatives A-D, total high water was greater in all four alternatives than in either Base (15-25 weeks as compared to ten weeks in the 2050 Base and three weeks in the 1995 Base). Extreme low water was somewhat reduced relative to both the 1995 and 2050 Bases; however, the Alternatives still predicted seven - eight extreme dry-downs lasting on average seven weeks duration. Although similar to NSM predictions for extreme low water, and slightly better than the 1995 base, the subteam was still concerned that this frequency of extreme dry-outs might not be low enough to protect peat soils.

Overall, because northern WCA-2A had a very non-NSM-like hydropattern, and because high and low depth extremes in southern WCA-2A create uncertainty about future marsh conditions in this area, the subteam assigned a score of “yellow” in the south and “red” in the north for all four Alternatives. However, it was also felt that performance, especially in the north, could be improved by changes in operational rules during future modeling efforts.

**WCA-2B (Indicator Region 23)**

WCA-2B was one of two regions in the northern and central Everglades that remained far from targeted performance for all four Alternatives. Although the number and duration of inundation events was a good match for NSM targets in all Alternatives A-D, extremes of high water, low water, or both led to poor performance in all cases.

Alternative A had the weakest performance. Although it showed substantial reduction in extreme low water compared to both bases and the other three alternatives, this improvement was offset by a dramatic 59% of time in which depths exceeded than 2.5 ft, a performance that was worse than even the 2050 Base, which had high water 56% of the time.

In contrast, Alternatives B-D succeeded in reducing extreme high water and providing improvement over both bases. Nonetheless, depths greater than 2.5 ft still occurred 10-11% of time in these alternatives, which is far from the NSM value of 1%. Furthermore, the frequency of extreme low water remained at 5% of time, which is still much higher than the NSM prediction of 1%.

These performance problems are consistent with the observation that WCA-2B is also the area that shows the largest deviation from NSM-like patterns of seasonal and interannual variability, with interannual standard deviations that are one-to-two times the magnitude of those seen in NSM. The reason for this is that WCA-2B experiences very high water during wet periods followed by long periods that are unnaturally dry. This is most pronounced in Alternative A. Overall, the subteam concluded that although Alternatives B, C, and D show significant improvement relative to both the 1995 and 2050 Bases, the frequent occurrence and long duration of extreme high and low water make it unlikely that this area would be able to function sustainably as either a shorter- or longer-hydroperiod Everglades wetland.

**Northwestern WCA-3A (Indicator Regions 20 and 22)**

NW WCA-3A was rated “green” for all four Alternatives A-D because all four models predict substantially reduced occurrence of extreme low water relative to both 1995 and 2050 Bases, while other performance measures are close to target values. In the northwest corner of WCA-3A (Indicator Region 22) dry-downs in excess of 1.0 ft below ground occurred on five - eight occasions for an average of 3-5 weeks duration (1-2% of total time). Slightly to the south, in Indicator Region 20, extreme dry-outs occurred somewhat more frequently, with nine low water events averaging five - sixweeks duration (3-4% of total time). Alternative C performed slightly better than Alternatives A, B, or D in both indicator regions. All four alternatives performed better than the 2050 Base and much better than the 1995 Base, which had as much as 11% extreme low water in Indicator Region 22. There remains some concern that the area represented by Indicator Region 20 may still be likely to experience more extreme low water than will be sufficient to protect peat soils. However, it may not be possible to further reduce low water events beyond performance levels comparable to Alternatives C and D without causing trade-offs, such as increased risk of cattail proliferation in ponded areas.

Along with the reduction in extreme low water, all four Alternatives performed as well or better than both bases at matching NSM inundation patterns. In addition, Indicator Region 20 had lower frequencies of extreme high water relative to both bases, with the best performance occurring in Alternatives A and B.

**Northeastern WCA-3A (Indicator Region 21)**

Alternative A performed best in this region, followed by Alternative B, although performance deficits occurred in all four alternatives. In general, this area has a problem with a tendency toward both too much high and low water.

For inundation pattern, Alternatives B, C, and D all did well at matching NSM target values. Alternative A, however, was similar to the 2050 Base, with fewer, longer periods of inundation than NSM. Overall, Alternative D came closet to matching the target values for inundation.

For low water extremes, however, Alternatives B, C and D all performed worse than the 2050, with 17 events averaging 7 weeks in Alternative B, 14 events averaging 6 weeks in Alternative C, and 15 events averaging 5 weeks in Alternative D. Although these values are similar to or less than those predicted by NSM for low water in this area, and all were substantial improvements over the 1995 Base, the subteam felt that the frequency (about one-in-two years) and duration (more than 1 month, on average) was larger than desired for protection of peat soils. Only Alternative A showed an improvement in low water extremes relative to the 2050 Base, and even it predicts 9 low water events averaging six weeks in length.

Alternative A was also the only Alternative that showed improvement over the 2050 Base with respect to extreme high water. Alternatives B, C, and D all exhibited an increase in the frequency of depths greater than 2.0 ft., with Alternatives C and D showing the least favorable performance. This creates concern about the effect of extreme high water on wading bird rookery vegetation in this region.

**Eastern WCA-3A (Indicator Region 19)**

None of the alternatives performed well in this area. The region, east of the Miami Canal and South of Alligator Alley, is deeply ponded in both 1995 and 2050 Bases and remains so in all four alternatives. Weekly mean depths greatly exceeded NSM targets, with Alternatives C and D being the deepest, having depths that exceed NSM by about 1-1.5 ft year round (see performance indicator, "Temporal Variation in Mean Weekly Stage for East WCA-3A"). Seasonal depth patterns in Alternatives A and B are similar to the 2050 and 1995 Bases but also exceed NSM depths by 1.0 ft or more through most of the year. As a consequence, only the performance measure for low water extremes shows good performance, in all except Alternative B.

High water extremes are most notable in this area. Alternatives C and D have depths greater than 2.5 ft 27% of the time. Alternative B, with 11% extreme high water, is similar in performance to the 2050 Base. Only Alternative A, with a high water frequency of 9%, predicts improvement over the 2050 Base. Although all the Alternatives show substantial improvement over the 53% of extreme high water predicted by the 1995 Base, none of them approaches the NSM target of 0% of time with depths greater than 2.5 ft.

Despite increased depths and frequent extreme high water, Alternative B also shows an increase in low water extremes relative to both Bases and the other Alternatives, with 11 events where depths dropped to more than 1.0 ft below ground, for an average of six weeks duration. This appears to be a consequence of the decompartmentalization of WCA-3 in Alternative B, which led to an increase in the frequency of both high and low extremes along the eastern side of the WCA (Indicator Regions 21 and 19), including WCA-3B (Indicator Region 16), and extending into northeast Shark River Slough (Indicator Region 11).

**Central and Southern WCA-3A (Indicator Regions 14, 17 and 18)**

**Indicator Region 14**

Alternative B performed best in this region. It is the only of the four alternatives in which extreme high water conditions (depths > 2.5 feet) did not occur; it is also the only alternative that had less extreme high water than the 2050 Base. However, only Alternative A had an inundation pattern that closely matched NSM, whereas Alternatives B, C, and D, all had fewer, more prolonged inundation periods, with Alternatives C and D being the wettest (11 wet periods averaging 139 weeks duration, as compared with NSM's 17 events averaging 88 weeks duration). The total percent inundation, however, was not dramatically different among the alternatives (92% in NSM, 94% in 2050 Base and Alternative B, and 95% in Alternatives A, C, and D). All were much improved over the extremely long hydroperiods seen in the 1995 Base. All four alternatives showed better matches for NSM's pattern of seasonal and interannual variation in depth than the 2050 Base.

**Indicator Region 17**

Alternatives A and B performed well in this region. They are the only alternatives in which high water conditions did not exceed 2.5 for more than 1% of the overall simulation period, and they are the only alternatives that had lower frequencies of extreme high water than the 2050 Base.

Performance for inundation pattern is more complex. The target for this area is 21 inundation events averaging 74 weeks duration, which is the average of NSM values for Indicator Regions 14 and 18. Only Alternative A and the 2050 Base had inundation patterns that closely matched this target. Alternatives B, C, D all had fewer and more prolonged inundation periods, with Alternative C being the wettest (13 inundation events averaging 118 weeks duration). Alternatives B and D are nearly identical to the 1995 Base; since this Indicator Region contains grid cells around the 3A-4 gage that are presently affected by ponding along the L67-A levee, this result suggests that Alternatives B and D are indeed somewhat wetter than would be ideal in this area.

**Indicator Region 18**

Alternative A and the 2050 Base both showed good hydrologic performance in this area. Both models exhibit an inundation pattern very similar to NSM, although both are also slightly drier than the 1995 Base. Alternatives B-D deviate greatly from target inundation patterns, with fewer than half the target number of events (10 events versus NSM’s 24), and mean durations about 2.5 times as long as target values (155-156 weeks versus NSM’s 59 weeks).

For high water extremes Alternatives C and D perform worse than either the 1995 or 2050 Bases, whereas Alternatives A and B show improvement over 1995 Base and are similar to 2050 Base, with extreme high water only about 1% of time. For low water extremes, all the alternatives were improvements over the 1995 and 2050 Bases; Alternative A, the driest overall, showed the least reduction in extreme low water, while Alternative B performed best.

**Overall, Indicator Regions 14, 17 and 18**

Overall, in southern and central WCA-3A, Alternatives A and B performed reasonably well, and Alternatives C and D performed poorly. Only Alternative A was effective at matching target inundation patterns throughout this region, with performance very similar to the 2050 Base. Alternatives B-D were all less successful than the 2050 Base at achieving target inundation patterns. This may be a result of Component RR4, which relocated and increased the capacity of the S-140 structure, causing increased water releases directly upstream of Indicator Region 18. Combined with increased volumes of water being moved through the WCA, this produced an overall reduction in the frequency of marsh dry-outs to ground surface and a general shift toward hydroperiods that are longer than NSM. The table below illustrates this effect: not only does the total percent inundation in Alternatives B-D exceed NSM values, but there is an inversion in the north-to-south gradient in hydroperiods, with the most northerly area (Indicator Region 18) having the longest percent inundation and the most southerly region (Indicator Region 14) the shortest. This is the opposite of NSM predictions for the pre-drainage gradient in hydroperiods in this region.

HYDROPERIODS FOR INDICATOR REGIONS IN SOUTH/CENTRAL WCA-3A

| Indicator Region | Target | 95BSR | 50BSR | Alt A | Alt B | Alt C | Alt D |
|---|---|---|---|---|---|---|---|
| IR 18 | 89% | 91% | 89% | 90% | 97% | 96% | 97% |
| IR 17 | *91% | 95% | 88% | 88% | 95% | 95% | 96% |
| IR 14 | 92% | 99% | 94% | 95% | 94% | 95% | 95% |

*(Target is the average of NSM for Indicator Regions 14 and 18.)

Although Alternative A was best at matching inundation targets, Alternative B was the only Alternative that effectively eliminated flooding of tree islands during high rainfall years. Hence, although Alternative A, on balance, showed the best overall performance in the central and southern WCA-3A, none of the alternatives was completely successful at meeting hydrologic performance goals for this region.

**WCA-3B (Indicator Regions 15 and 16)**

In this area, only Alternative A approaches target hydrologic conditions for WCA-3B. Alternative B is least favorable, primarily owing to predicted high water extremes that are comparable to those seen in WCA-2B in the 1995 Base.

WCA-3B exhibits increased depths in all four alternatives, with weekly mean depths that exceed NSM by 0.5-0.75 ft year round. Alternative B has the deepest water during the wet season, whereas Alternative D has the largest average dry season depths. With respect to inundation pattern, Alternative A was the only Alternative that matched NSM, and this only in the southeast (Indicator Region 16). In all other cases, all four Alternatives predicted fewer, longer duration inundation events than NSM. The poorest performer for inundation is Alternative D, which predicts only 5 and six inundation periods lasting an average of 319 and 262 weeks, as compared with NSM's prediction of 20 and 15 events averaging 74 and 102 weeks, for Indicator Regions 15 and 16, respectively. Generally, in western WCA-3B only the 2050 Base is a good match for NSM inundation patterns, and in southeast WCA-3B, only Alternative A and the 1995 Base approach target values.

For low water extremes, all four alternatives show improvement relative to the 2050 Base. In southeastern WCA-3B, however, all four alternatives had more extreme low water than NSM. Of the four models, Alternative B had the largest total amount of extreme low water (9 and 16 weeks in Indicator Regions 15 and 16, respectively), while Alternatives A and D had the fewest weeks (0 and 11 weeks in Alternative A; 1 and 7 weeks in Alternative D).

The most serious performance issue for WCA-3B is the high predicted frequency of extreme high water. Alternative A was the only of the four alternatives that met target values for extreme high water, with slightly fewer total high water weeks than those predicted by NSM. Relative to the 1995 Base, Alternative A has a slight increase in high water in the western WCA-3B but a decrease in eastern WCA-3B; Alternative A also performed better than the 2050 Base in both

areas. Overall, only the 1995 Base and Alternative A achieved target values for high water extremes. The percents of time with extreme high water are listed in the table below for the four Alternatives, the Bases, and NSM. For comparison, the table also includes NSM values for Indicator Regions in Shark River Slough, as well as 1995 Base values for some Indicator Regions in areas that experience extreme depths under current C&SF Project conditions. It can be seen that Alternatives B-D all substantially exceed targets for both Indicator Regions 15 and 16. Alternative B has the most extreme high water, equivalent to an average 3 month period with depths over 2.5 ft that would occur in approximately two out of every three years. When the Alternatives are compared to the 1995 Base values for Indicator Regions representing currently deeply-ponded areas of the WCA system, it appears that impacts, even in Alternative B, would not be as extreme as those experienced to date in other areas.
However, NSM values from the table suggest that the deepest areas of the pre-drainage Everglades had depths greater than 2.5 ft for up to 9% of time; hence, Alternative B, with 12-17% high water, is predicted to produce conditions outside the range for the pre-drainage system. Such depths and durations would be expected to cause significant damage to tree island vegetation communities in WCA-3B.

Percent of Time Depths Exceeded 2.5 ft in Selected Indicator Region

| | Western WCA-3B Indicator Region 15 | Eastern WCA-3B Indicator Region 16 |
|---|---|---|
| Base Cases: | | |
| 95BSR | 1% | 3% |
| 50BSR | 5% | 8% |
| Alternatives: | | |
| Alternative A | 2% | 2% |
| Alternative B | 12% | 17% |
| Alternative C | 6% | 9% |
| Alternative D | 8% | 10% |
| NSM Target: | 2% | 4% |
| Other NSM Values: | | |
| Mid Shark Slough | 4% | |
| NE Shark Slough | 9% | |
| Other 1995 Base Values (currently deep areas of WCA system) : | | |
| (IR 23: WCA-2B) | 17% | |
| (IR 26: S LNWR) | 30% | |
| (IR 14: S WCA-3A) | 36% | |
| (IR 19: E WCA-3A) | 53 % | |

**Pennsuco Wetlands (Indicator Regions 52 and 53)**

Extreme low water occurs infrequently in Alternatives C and D (1-3% of time), compared with Alternative B (2-4%), Alternative A (3-6%), and especially the 1995 and 2050 Bases (7-10% and 9-13% , respectively). High water extremes occur less frequently in all alternatives than under NSM, with Alternative A showing the best performance. The overall inundation pattern varies between the north and south. In northern Pennsuco (Indicator Region 52), Alternatives A, B, and C all show good matches for NSM inundation patterns, whereas Indicator Region 53 comes closest to NSM in Alternative D. The NSM inundation pattern in Indicator Region 52 is similar to that for WCA-3B and southern WCA-3A, which is probably a more appropriate and achievable target for this area than is the deeper Shark Slough-like conditions seen in NSM for Indicator Region 53. Overall, Alternative D appears to provide the best overall hydrologic performance for this area.

**Overall N/C Everglades Performance in Alternatives A-D**

The four Alternatives performed similarly in the final evaluations over a large area of the N/C Everglades. Performance was fairly uniformly good in LNWR, Holey Land and Rotenberger WMAS, and northwest WCA-3A. Performance was uniformly poor in WCA-2B and eastern WCA-3A, and was uniformly problematic and uncertain in its implications for WCA-2A.

Where the four alternatives exhibited major differences in performance was in WCA-3B and in southern, central, and northeastern WCA-3A. In these areas, Alternative A provided the best overall hydrologic performance. Alternative B performed very well in Southern and Central WCA-3A by largely eliminating extreme high water, but this was offset by poor performance in northeastern WCA-3A, an area with important wading bird breeding habitat, and by extremely poor performance in WCA-3B, where extreme high water would be expected to damage tree islands. Alternatives C and D performed poorly in WCA-3B, and were the least favorable Alternatives in central, southern and northeastern WCA-3A.

In conclusion, all of the alternatives provided improved conditions relative to the 2050 Base in parts of the northern and central Everglades, but only Alternative A came close to meeting performance targets in a majority of areas, yet it did not prevent extreme high water likely to damage tree island and rookery vegetation in WCA-3A. The only alternative that effectively avoided extreme high water in WCA-3A was Alternative B, and these benefits were offset by high water extremes in WCA-3B. Since south/central WCA-3A and WCA-3B represent the parts of the WCA 2-3 system that have been least damaged by the C&SF Project to-date, and since northeastern WCA-3A is home to currently important wading bird rookery sites, it appears that none of the four Alternatives A-D can presently be regarded as likely to provide for overall restoration and sustainability of an Everglades sawgrass and ridge-and-slough ecosystem within the area encompassed by WCAs 2 and 3.

Evaluation of Alternative D13R

**Subarea Evaluations**

**Loxahatchee NWR (Indicator Regions 26 and 27)**

Loxahatchee NWR performs identically in Alternative D13R and Alternative D. The overall hydrology is similar to the 1995 Base planning target, and inundation patterns in the north are improved over the drier predictions of the 2050 Base.

**Holey Land and Rotenberger WMAs (Indicator Regions 28 and 29)**

Holey Land and Rotenberger WMAs perform nearly identically in Alternatives D and D13R. The regulation schedule assumed for Rotenberger WMA appears to eliminate high water extremes effectively while maintaining suitable NSM-like inundation patterns. In Holey Land, depths greater than 1.5 ft occur 7% of time, but depths greater than 1.75 ft occur only about 1% of time. In both WMAs, the frequencies and durations of extreme low water are less than those predicted by NSM; however, drought conditions still occupy 3-4% of the simulation period. Although there is uncertainty about the exact conditions needed to protect peat soils, so long as the alternative provides dry season deliveries via the STAs, it should be possible to adjust operational details so as to avoid further soil loss in these areas.

**WCA-2A (Indicator Regions 24 and 25)**

Overall, operational changes between Alternatives D and D13R improved performance in northern WCA-2A but reduced performance in the south. While southern WCA-2A experienced more drought conditions in Alternative D13R than in Alternative D, northern WCA-2A experienced improved inundation patterns. In the south (Indicator Region 24), extreme low water occurred 12 times averaging seven weeks in duration; this performance is inferior to the 1995 and 2050 bases and could potentially promote soil loss. In the north (Indicator Region 25), extreme low water occurred less frequently (four times averaging nine weeks duration) than in Alternative D, with frequencies that were comparable to the 2050 Base and an improvement over the 1995 Base.

Inundation patterns in northern WCA-2A were substantially improved over Alternative D. Alternative D13R had 16 wet periods averaging 93 weeks duration, in contrast to Alternative D which had only nine periods averaging 173 weeks in length. Although neither alternative matches the NSM target of 30 events averaging 46 weeks duration, Alternative D13R comes considerably closer to the target here than does Alternative D.

It appears that water management in WCA-2A imposes trade-offs between providing improved marsh conditions in some areas but worse conditions in others. Overall, the subteam tentatively favored Alternative D13R's performance; however, a more rigorous examination of predicted conditions and effects of different operational rules will be needed in order to provide the best hydrology to those areas expected to yield the most ecological benefits. Historically, southern WCA-2A has lost most of its tree islands to past high water, while many acres of northern WCA-2A have been overtaken by cattails. The highest quality marsh occurs in central WCA-2A in the vicinity of the 2-17 gage, and to the northwest where tree islands still persist. Inspection of stage duration curves for the 2-17 gage grid cell indicate that Alternatives D and D13R are nearly identical, and that both have possibly increased high water frequencies compared to the 1995 and 2050 bases. Hence, implementation of the plan will require careful evaluation of hydrologic objectives in light of performance constraints for this area.

**WCA-2B (Indicator Region 23)**

WCA-2B was the only region of the northern and central Everglades to receive a "red" color evaluation for Alternative D13R. The reason for this rating is that the alternative continues to have high frequencies of both high and low water extremes. High water extremes are substantially improved over the 1995 and 2050 bases, and the number and duration of inundation events is a good match for NSM targets. However, the combination of frequent extreme low water (14 events occupying 6% of total time) and frequent extreme high water (25 events occupying 10% of total time) make it unlikely that this area will be able to function sustainably as either a shorter- or longer-hydroperiod Everglades wetland.

**Northwestern WCA-3A (Indicator Regions 20 and 22)**

This region performs similarly in Alternative D13R and Alternative D. Inundation patterns match NSM planning targets and high water extremes are minimal. Low water extremes occur five times for an average of three weeks duration in Indicator Region 22, and nine times for an average of five weeks in Indicator Region 20. This is a substantial improvement over the 2050 Base, and an even larger improvement relative to the 1995 Base. Conditions in this region are thus expected to maintain and promote peat soils. However, there continues to be uncertainty as to whether increased wet conditions will lead to undesirable proliferation of cattails in this area.

**Northeastern WCA-3A (Indicator Region 21)**

Performance of Alternative D13R is problematic, owing to predicted frequencies of extreme high and low water. The frequency of high water is increased in comparison to both the 1995 and 2050 bases, with periods of continuous depths above 2.0 ft occurring six times for an average of seven weeks in duration. During rainfall year 1994, simulated peak depths and flood durations in Alternative D13R are similar to the 1995 Base, while during rainfall year 1995, depths are deeper and of longer duration than the 1995 Base. This suggests that during high-rainfall years comparable to 1994-95, flooding can be expected to be worse than what actually occurred in this area during 1994-95. This increase in predicted high water raises concerns about potential negative effects on wading bird nesting habitat in this region. One of the most successful nesting sites for wading birds in recent years, Rescue Strand, suffered loss of perhaps as much as 75% of its willows during the 1994-95 high water period (T. Towles, GFC, pers. comm.). This rookery site is located in the same model grid cell as the 3A-3 gage, where stage hydrograph output indicates that, although depths in Alternative D13R are predicted to be lower than the 1995 Base in normal and dry years, during the wettest years (1969-70 and 1994-95) depths are predicted to equal or exceed the 1995 Base. This suggests that willow islands suitable for wading bird nesting in this area would likely be damaged, or possibly destroyed, by high water events. The problem appears to arise from the operation of STA 3/4 during peak rainfall years, when STA operational rules override marsh triggers and lead to excess discharges into this area. Changes in STA operations, additional storage, or re-routing of flood waters might alleviate or reverse this negative impact. In addition, interpretation of net impacts for wading birds is complicated by the fact that conditions to the south of the 3A-3 gage are predicted to be drier than in the 1995 Base. Hence rookery sites in eastern WCA-3A might be expected to do better under Alternative D13R than under current conditions.

An additional source of uncertainty in this area is the high predicted frequency of low water extremes. Alternative D13R performs best of all the alternatives in reducing low water extremes relative to both base cases (15 events averaging four weeks duration as compared to 21 events averaging nine weeks in the 1995 Base, and ten events averaging seven weeks in the 2050

Base). Nonetheless, the predicted frequency and duration of low water events seems large, and may not insure protection of peat soils.

**Eastern WCA-3A (Indicator Region 19)**

In this area, Alternative D13R has a very similar inundation pattern to Alternative D and to the 2050 Base. Although depths are much greater than NSM, they are lower than in Alternative D and much lower than the 1995 Base. High water extremes are dramatically reduced relative to Alternative D (19% in Alternative D13R compared to 27% in Alternative D). Although this performance is not as good as in the 2050 Base (with only 11% high water), and although Alternative D13R remains far from the NSM target of 0% high water, there is nonetheless enormous improvement relative to the 1995 Base prediction of 53% high water. It seems likely that this is a result of changed operations and retention of a portion of the L-67A canal, which allows more rapid removal of water from this area. Generally, eastern WCA-3A is far from its target values. However, unlike predictions for WCA-2B, extreme high water is not combined with an equivalent frequency of extreme low water. For this reason, the subteam scored the area as "yellow" rather than "red," reasoning that predicted conditions in eastern WCA-3A might support suitable habitat for snail kites and other organisms that depend on deeper water.

**Central and Southern WCA-3A (Indicator Regions 14, 17 and 18)**

Because performance differed distinctly among the three indicator regions in this area, results are described separately for each.

**Indicator Region 14: Green.**

Alternative D13R performed much better than Alternative D in this area. Most notably, depths exceeded 2.5 ft only 1% of total time, compared with 6% in Alternative D. This is a substantial improvement over the 2050 Base, with 6% high water, and a dramatic improvement over the 1995 Base, which had depths greater than 2.5 ft for 36% of the total simulation. Performance in reducing high water extremes was similar but not quite as successful as Alternative B, the alternative with the best overall performance in this indicator region.

Alternative D13R, however, has more prolonged inundation than target values, averaging 139 weeks inundation duration versus 88 weeks in NSM. This pattern is slightly wetter than the longest inundation periods predicted by NSM for the northern and central Everglades, but it is still "NSM-like," with dry-outs to ground surface averaging about once every three years. Hence, Alternative D13R was rated "green" because of its superior performance in reducing extremes of high water, while maintaining less than 1% of extreme low water. Overall, predicted hydrologic conditions in this area would be expected to promote recovery and persistence of tree island vegetation communities.

**Indicator Region 17: Green.**

Alternative D13R performed very well in this region. Extreme high water conditions occurred only 1% of time, which is one-half the frequency in the 2050 Base and about one-fourth the frequency in the 1995 Base. This performance was similar but slightly inferior to that seen in Alternative B, the best alternative at reducing overall high water frequencies in southern and central WCA-3A. The frequency of extreme low water did not increase in Alternative D13R relative to Alternative D, and low water performance remained slightly better than the 1995 and 2050 bases.

However, Alternative D13R experienced fewer dry-outs to ground surface than its target value (14 inundation events versus a target of 21 events), with more prolonged periods of inundation (110 weeks average duration versus a target of 74 weeks). This is similar to the longer-than-NSM inundation periods seen in Indicator Regions 14 and 18.

Indicator Region 18: Yellow

In this region, Alternative D13R, like Alternative D, has a predicted inundation pattern that is much wetter than NSM. Inundation periods average 142 weeks as compared with 59 weeks for NSM, and the number of wet periods is less than half the target value (11 versus 24 events). Both the 1995 Base and the 2050 Base are better matches for NSM inundation patterns. Despite long inundation periods, however, this indicator region, like Indicator Regions 14 and 17 to the south, shows reduced occurrence of extreme high water relative to the 1995 Base, suggesting that tree island flooding will be alleviated in Alternative D13R. At the same time, low water extremes do not increase, but are actually fewer in number than in the 1995 and 2050 bases.

Overall, for central and southern WCA-3A as a whole, the principle source of uncertainty in Alternative D13R is the ecological effect of increased inundation durations, with fewer marsh dry-outs, especially within the relatively pristine area spanned by Indicator Regions 17 and 18. Indicator Region 17 dries out with about the same frequency as in the 1995 Base; however, Indicator Region 18 dries out less frequently. This appears to be a result of the large inflows from the S-140 structure in Alternative D13R, which passes water into and through Indicator Region 18 throughout the dry season, thus preventing the marsh from drying out in most years.

Alternative D13R is expected to be highly beneficial for tree island communities in central and southern WCA-3A. All three indicator regions show greatly reduced frequencies of extreme high water. Extreme flooding is not predicted to occur even during high rainfall years comparable to 1994-95. Furthermore, removal of the L-29 levee eliminates barriers to rapid recession of flood waters, which would be expected to help limit flooding even under more extreme rainfall conditions than those simulated in the model.

**WCA-3B (Indicator Regions 15 and 16)**

Alternative D13R significantly reduced the frequency of extreme high water in WCA-3B compared to Alternative D. In western WCA-3B (Indicator Region 15) Alternative D had depths that exceeded 2.5 ft for 8% of total time; this decreased to 3% of total time in Alternative D13R. In southeastern WCA-3B (Indicator Region 16), Alternative D had 10% extreme high water, and this decreased to 5% in Alternative D13R. High water performance is also better than in the 2050 Base, which had high water 5% and 8% of time in Indicator Regions 15 and 16, respectively. However, high water performance did not meet the NSM-defined targets for these areas, which predict less than 2% high water in Indicator Region 15 and less than 4% in Indicator Region 16. Only the 1995 Base and Alternative A achieved target values for high water extremes. Although Alternative D13R appears to reduce high water extremes to levels likely to prevent damage to higher hammock tree islands in WCA-3B, impacts on less-elevated tree islands still may occur.

A second source of uncertainty in Alternative D13R is the very long duration of inundation in WCA-3B relative to NSM values for the area. Western WCA-3B (Indicator Region 15) has only four inundation periods in 31 years, hence only about four dry-outs to ground level, and these inundation periods average 398 weeks in length. In eastern WCA-3B (Indicator Region 16), there are six inundation periods that average 262 weeks duration. These results differ substantially from NSM values of 20 events averaging 74 weeks, and 15 events averaging 102 weeks, in Indicator Regions 15 and 16, respectively. Both the 1995 and 2050 bases, as well as Alternative A, are better matches for NSM inundation patterns than is Alternative D13R.

Given removal of the eastern L-29 levee in Alternatives B, C, D, and D13R, combined with restoration of long hydroperiods and deeper water in NE Shark Slough, it appears logically inevitable that water depths and inundation durations in WCA-3B would increase. Overall, this creates an inundation and depth pattern in WCA-3B that more closely matches NSM predictions for mid-Shark River Slough than for WCA-3B itself. Because this represents a substantial deviation from both NSM predictions of the pre-drainage hydrology of the area and current conditions in WCA-3B, extreme caution should be used in implementing changes that include such a potentially high degree of uncertainty as to the biological response to change in hydrology.

**Pennsuco Wetlands (Indicator Regions 52 and 53)**

Extreme low water occurs infrequently in Alternative D13R (1-2% of time); this is an improvement over Alternatives A-C (3-4% low water), and a dramatic improvement relative to both 1995 and 2050 bases (7-10% and 9-13% low water, respectively). High water extremes are also rare and occur much less frequently than under NSM. The overall inundation pattern in Alternative D13R differs from NSM predictions, with Indicator Region 52 having fewer inundation events than NSM, while Indicator Region 53 has more than NSM. Inundation durations are significantly increased relative to both the 1995 and 2050 bases. Overall, Alternative D13R predicts "NSM-like" ridge and slough conditions with reduced drought frequencies. This would be expected to protect marsh soils and provide for a sustainable marsh in the area.

Summary Evaluation for Alternative D13R

Alternative D13R appears to provide the best overall performance for the WCA system. While all the alternatives perform well with respect to drought conditions that could damage peat soils, Alternative D13R provides the best overall reduction in extreme high water conditions that would flood out tree island vegetation communities, especially in southern WCA-3A and WCA-3B. Thus, Alternative D13R appears to make substantial progress toward solving the two most significant problems that have resulted from the C&SF Project in this region of the Everglades.

Two notable areas of uncertainty remain, however. One of these is the effect on wading bird populations of changes in depth patterns in northeastern WCA-3A. The more northerly parts of this area (represented by model output for the 3A-3 gage and Indicator Region 21) are predicted to become wetter, while to the south, areas east of the Miami Canal will remain deeper than NSM but will have much reduced high water frequencies compared to the 1995 Base. These conditions could be expected to improve suitable rookery sites in some areas but possibly damage others, and the distribution of suitable foraging areas will undoubtedly be changed. Although overall restoration of the Everglades watershed is expected to improve wading bird nesting habitat regionally, the timing of development of suitable breeding sites to the south of Tamiami Trail, relative to changes in current nesting sites, could have significant effects on regional wading bird populations. A more detailed analysis of anticipated effects of Alternative D13R on wading bird breeding and foraging habitat, combined with a plan for system-wide monitoring, will be important components in implementing the plan.

The second major area of uncertainty is the effect of a shift in the overall hydrologic pattern toward longer periods of inundation with fewer drying events than those predicted by NSM. The best overall match to NSM inundation patterns is Alternative A, where it appears that maintenance of the WCAs as compartments provides more control over water depths in different sections of the Everglades. With partial decompartmentalization such as that in Alternatives B and D13R, exact matches to local NSM predictions for the indicator regions in WCA-3 no longer appear to be possible, given the reduced overall extent of the Everglades watershed north of Tamiami Trail. Hence, the benefits of decompartmentalization in promoting sheetflow and reducing the frequency and duration of flooding appear to conflict with the ability of water management to match local NSM targets. In considering this apparent trade-off, the subteam concluded that the long-term sustainability of the northern and central Everglades marshes probably depended more on the avoidance of extremes of drought and flood than on exact restoration of local pre-drainage hydropatterns. Only Alternatives B and D13R manage to avoid extreme high water in southern and central WCA-3A, and only Alternative D13R accomplishes this in WCA-3B as well.

In conclusion, Alternative D13R provides inundation patterns that are "NSM-like" and that seem likely to promote a sustainable Everglades ecosystem. There nonetheless remain many uncertainties about the biological response that will occur, and these uncertainties can only be overcome by a suitable plan for adaptive management that will allow timely and informed changes in water management as deemed necessary to promoting biological restoration goals.

**Table Northern and Central Everglades - 1**

**INUNDATION PATTERN -- Index Values**

| **Loxahatchee NWR** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| South | 26 | 28 | 1.0 | 0.2 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 |
| North | 27 | 28 | 1.0 | 0.5 | 0.6 | 0.8 | 0.9 | 0.9 | 0.9 |
| **Average** | | | **1.0** | **0.4** | **0.8** | **0.9** | **0.9** | **0.9** | **0.9** |

| **Holey Land and Rotenberger** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| Rotenberger WMA | 28 | 10 | 0.7 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Holey Land WMA | 29 | 14 | 0.3 | 0.2 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Average** | | | **0.4** | **0.5** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** |

| **WCA-2A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| South | 24 | 19 | 1.0 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 |
| North | 25 | 19 | 0.3 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | 0.3 |
| **Average** | | | **0.7** | **0.7** | **0.6** | **0.6** | **0.6** | **0.6** | **0.6** |

| **WCA-2B** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| | **23** | **11** | **1.0** | **0.9** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** |

| **Northwestern WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| NW | 20 | 23 | 0.5 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| NW Corner | 22 | 23 | 0.4 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Average** | | | **0.4** | **0.9** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** |

| **Northeastern WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| | **21** | **21** | **0.6** | **0.7** | **0.5** | **1.0** | **0.9** | **1.0** | **1.0** |

| **East WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| | **19** | **29** | **0.1** | **0.4** | **0.5** | **0.7** | **0.2** | **0.3** | **0.3** |

| **Central and Southern WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| South | 14 | 36 | 0.2 | 1.0 | 1.0 | 0.7 | 0.6 | 0.8 | 0.6 |
| South Central | 17 | 36 | 0.6 | 0.9 | 0.9 | 0.6 | 0.5 | 0.7 | 0.6 |
| North Central | 18 | 36 | 0.7 | 0.9 | 0.9 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Average** | | | **0.7** | **0.9** | **0.9** | **0.4** | **0.4** | **0.5** | **0.4** |

| **WCA-3B** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| West | 15 | 13.5 | 0.3 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| East | 16 | 13.5 | 0.9 | 0.3 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 |
| **Average** | | | **0.6** | **0.6** | **0.7** | **0.4** | **0.3** | **0.1** | **0.1** |

| **Pennsuco** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| North | 52 | 3.5 | 0.4 | 0.6 | 1.0 | 0.9 | 0.9 | 0.3 | 0.5 |
| South | 53 | 3.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.5 | 0.2 |
| **Average** | | | **0.2** | **0.4** | **0.6** | **0.5** | **0.5** | **0.4** | **0.3** |

**Northern and Central Everglades**
**HIGH WATER EXTREMES -- Index Values**
June 26, 1998

| Loxahatchee NWR | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| South | 26 | 28 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| North | 27 | 28 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Average** | | | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** | **1.0** |

| Holey Land and Rotenberger | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| Rotenberger WMA | 28 | 10 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Holey Land WMA | 29 | 14 | 0.0 | 0.0 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Average** | | | **0.4** | **0.4** | **0.7** | **0.7** | **0.7** | **0.7** | **0.7** |

| WCA-2A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| South | 24 | 19 | 0.6 | 0.4 | 0.3 | 0.2 | 0.2 | 0.1 | 0.3 |
| North | 25 | 19 | 1.0 | 0.9 | 1.0 | 0.8 | 0.8 | 0.6 | 0.6 |
| **Average** | | | **0.8** | **0.7** | **0.7** | **0.5** | **0.5** | **0.4** | **0.5** |

| WCA-2B | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| | **23** | **11** | **0.0** | **0.0** | **0.0** | **0.3** | **0.4** | **0.4** | **0.4** |

| Northwestern WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| NW | 20 | 23 | 0.5 | 0.5 | 1.0 | 1.0 | 0.7 | 0.7 | 0.9 |
| NW Corner | 22 | 23 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Average** | | | **0.7** | **0.8** | **1.0** | **1.0** | **0.9** | **0.9** | **1.0** |

| Northeastern WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| | **21** | **21** | **0.6** | **0.5** | **0.9** | **0.4** | **0.1** | **0.1** | **0.2** |

| East WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| | **19** | **29** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** |

| Central and Southern WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| South | 14 | 36 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.3 |
| South Central | 17 | 36 | 0.0 | 0.1 | 0.2 | 0.5 | 0.2 | 0.1 | 0.3 |
| North Central | 18 | 36 | 0.1 | 0.3 | 0.4 | 0.3 | 0.2 | 0.1 | 0.2 |
| **Average** | | | **0.1** | **0.2** | **0.3** | **0.4** | **0.2** | **0.1** | **0.3** |

| WCA-3B | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| West | 15 | 13.5 | 0.7 | 0.6 | 0.8 | 0.1 | 0.3 | 0.1 | 0.7 |
| East | 16 | 13.5 | 1.0 | 0.5 | 1.0 | 0.3 | 0.5 | 0.5 | 0.5 |
| **Average** | | | **0.9** | **0.5** | **0.9** | **0.2** | **0.4** | **0.3** | **0.6** |

**Table Northern and Central Everglades - 3**

**LOW WATER EXTREMES -- Index Values**

| **Loxahatchee NWR** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| South | 26 | 28 | 1.0 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| North | 27 | 28 | 0.8 | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 |
| **Average** | | | **0.9** | **0.7** | **0.9** | **0.9** | **0.9** | **0.9** | **0.9** |

| **Holey Land and Rotenberger** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| Rotenberger WMA | 28 | 10 | 0.4 | 0.7 | 0.7 | 0.8 | 0.7 | 0.8 | 0.8 |
| Holey Land WMA | 29 | 14 | 0.9 | 0.9 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| **Average** | | | **0.7** | **0.8** | **0.7** | **0.7** | **0.8** | **0.8** | **0.8** |

| **WCA-2A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| South | 24 | 19 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.4 |
| North | 25 | 19 | 0.5 | 0.6 | 0.9 | 0.9 | 1.0 | 1.0 | 0.7 |
| **Average** | | | **0.5** | **0.6** | **0.7** | **0.7** | **0.8** | **0.8** | **0.6** |

| **WCA-2B** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| | **23** | **11** | **0.2** | **0.2** | **0.5** | **0.3** | **0.3** | **0.3** | **0.2** |

| **Northwestern WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| NW | 20 | 23 | 0.3 | 0.3 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| NW Corner | 22 | 23 | 0.2 | 0.4 | 0.7 | 0.6 | 0.8 | 0.7 | 0.8 |
| **Average** | | | **0.2** | **0.4** | **0.6** | **0.5** | **0.6** | **0.6** | **0.7** |

| **Northeastern WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| | **21** | **21** | **0.4** | **0.7** | **0.8** | **0.6** | **0.7** | **0.7** | **0.7** |

| **East WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| | **19** | **29** | **1.0** | **0.8** | **0.9** | **0.6** | **0.9** | **0.9** | **0.8** |

| **Central and Southern WCA-3A** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| South | 14 | 36 | 1.0 | 0.7 | 0.6 | 0.7 | 0.8 | 0.8 | 0.7 |
| South Central | 17 | 36 | 0.8 | 0.5 | 0.5 | 0.7 | 0.8 | 0.8 | 0.9 |
| North Central | 18 | 36 | 0.6 | 0.5 | 0.6 | 0.7 | 0.9 | 0.9 | 0.7 |
| **Average** | | | **0.7** | **0.5** | **0.5** | **0.7** | **0.8** | **0.8** | **0.8** |

| **WCA-3B** | **IR** | **weight** | **95BSR** | **50BSR** | **ALT A** | **ALT B** | **ALT C** | **ALT D** | **ALT D13R** |
|---|---|---|---|---|---|---|---|---|---|
| West | 15 | 13.5 | 0.7 | 0.3 | 1.0 | 0.4 | 0.7 | 0.9 | 0.6 |
| East | 16 | 13.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 |

**Table Northern and Central Everglades-4**

**AVERAGE INDEX VALUES***

| Loxahatchee NWR | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| South | 26 | 28 | 1.0 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| North | 27 | 28 | 0.9 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 |
| **Average** | | | **1.0** | **0.8** | **0.9** | **0.9** | **0.9** | **1.0** | **1.0** |

| Holey Land and Rotenberger | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| Rotenberger WMA | 28 | 10 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Holey Land WMA | 29 | 14 | 0.4 | 0.4 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| **Average** | | | **0.5** | **0.6** | **0.8** | **0.8** | **0.8** | **0.8** | **0.8** |

| WCA-2A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| South | 24 | 19 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| North | 25 | 19 | 0.7 | 0.7 | 0.8 | 0.7 | 0.8 | 0.7 | 0.6 |
| **Average** | | | **0.7** | **0.6** | **0.7** | **0.6** | **0.7** | **0.6** | **0.5** |

| WCA-2B | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| | **23** | **11** | **0.3** | **0.3** | **0.4** | **0.4** | **0.4** | **0.5** | **0.4** |

| Northwestern WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| NW | 20 | 23 | 0.4 | 0.5 | 0.8 | 0.8 | 0.7 | 0.7 | 0.8 |
| NW Corner | 22 | 23 | 0.6 | 0.8 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 |
| **Average** | | | **0.5** | **0.6** | **0.8** | **0.8** | **0.8** | **0.8** | **0.8** |

| Northeastern WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| | **21** | **21** | **0.5** | **0.6** | **0.8** | **0.6** | **0.5** | **0.5** | **0.6** |

| East WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| | **19** | **29** | **0.4** | **0.4** | **0.5** | **0.4** | **0.5** | **0.4** | **0.4** |

| Central and Southern WCA-3A | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| South | 14 | 36 | 0.4 | 0.5 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 |
| South Central | 17 | 36 | 0.4 | 0.4 | 0.5 | 0.6 | 0.6 | 0.5 | 0.6 |
| North Central | 18 | 36 | 0.4 | 0.5 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| **Average** | | | **0.4** | **0.5** | **0.5** | **0.6** | **0.5** | **0.5** | **0.5** |

| WCA-3B | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| West | 15 | 13.5 | 0.6 | 0.6 | 0.8 | 0.3 | 0.5 | 0.4 | 0.5 |
| East | 16 | 13.5 | 0.6 | 0.3 | 0.6 | 0.2 | 0.2 | 0.3 | 0.2 |
| **Average** | | | **0.6** | **0.4** | **0.7** | **0.3** | **0.4** | **0.3** | **0.4** |

| Pennsuco | IR | weight | 95BSR | 50BSR | ALT A | ALT B | ALT C | ALT D | ALT D13R |
|---|---|---|---|---|---|---|---|---|---|
| North | 52 | 3.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| South | 53 | 3.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 |
| **Average** | | | **0.5** | **0.5** | **0.5** | **0.5** | **0.5** | **0.6** | **0.5** |

*Index value = (0.2)(inundation index)+(0.4)(high extremes index)+(0.4)(low extremes index)

NOTE: these values are intended for ranking purposes only; values are not meaningful as measures of ecological restoration potential.

July 7, 1998

N/C EVERGLADES SUMMARY RANKS FOR 2050 BASE and ALTERNATIVES A-D
& AREA COLOR AND LETTER GRADE SCORES FOR ALTERNATIVES A-D

| | weights | 50B | 50B | 50B | 50B | AltA | AltA | AltA | AltA | AltA | AltA | AltB | AltB | AltB | AltB | AltB | AltB | AltC | AltC | AltC | AltC | AltC | AltC | AltD | AltD | AltD | AltD | AltD | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indicator Region | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 26 South LNWR (WCA-1) | 28.0 | 5.0 | 3.0 | 5.0 | **4.3** | 1.5 | 3.0 | 2.5 | **2.3** | **G** | | 3.5 | 3.0 | 2.5 | **3.0** | **G** | | 3.5 | 3.0 | 2.5 | **3.0** | **G** | | 1.5 | 3.0 | 2.5 | **2.3** | **G** | |
| 27 North LNWR (WCA-1) | 28.0 | 4.5 | 3.0 | 5.0 | **4.2** | 4.5 | 3.0 | 4.0 | **3.8** | **G** | | 3.0 | 3.0 | 2.5 | **2.8** | **G** | | 1.5 | 3.0 | 2.5 | **2.3** | **G** | | 1.5 | 3.0 | 1.0 | **1.8** | **G** | |
| AVERAGE | | 4.8 | 3.0 | 5.0 | 4.2 | 3.0 | 3.0 | 3.3 | 3.1 | G | A | 3.3 | 3.0 | 2.5 | 2.9 | G | A | 2.5 | 3.0 | 2.5 | 2.7 | G | A | 1.5 | 3.0 | 1.8 | 2.1 | G | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 28 Rotenberger WMA | 10.0 | 3.0 | 3.0 | 3.0 | **3.0** | 3.0 | 3.0 | 3.0 | **3.0** | **G** | | 3.0 | 3.0 | 3.0 | **3.0** | **G** | | 3.0 | 3.0 | 3.0 | **3.0** | **G** | | 3.0 | 3.0 | 3.0 | **3.0** | **G** | |
| 29 Holey Land WMA | 14.0 | 5.0 | 5.0 | 1.0 | **3.7** | 5.0 | 2.5 | 3.5 | **3.7** | **G** | | 2.5 | 2.5 | 3.5 | **2.8** | **G** | | 2.5 | 2.5 | 3.5 | **2.8** | **G** | | 2.5 | 2.5 | 3.5 | **2.8** | **G** | |
| AVERAGE | | 4.2 | 4.2 | 1.8 | 3.4 | 4.2 | 2.7 | 3.3 | 3.4 | G | B | 2.7 | 2.7 | 3.3 | 2.9 | G | B | 2.7 | 2.7 | 3.3 | 2.9 | G | B | 2.7 | 2.7 | 3.3 | 2.9 | G | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 24 South WCA-2A | 19.0 | 4.5 | 1.0 | 4.5 | **3.3** | 4.5 | 2.0 | 4.5 | **3.7** | **Y** | | 2.0 | 4.0 | 2.0 | **2.7** | **Y** | | 2.0 | 4.0 | 2.0 | **2.7** | **Y** | | 2.0 | 4.0 | 2.0 | **2.7** | **Y** | |
| 25 North WCA-2A | 19.0 | 1.0 | 2.0 | 5.0 | **2.7** | 2.0 | 1.0 | 3.5 | **2.2** | **R** | | 4.0 | 3.5 | 3.5 | **3.7** | **R** | | 4.0 | 3.5 | 1.5 | **3.0** | **R** | | 4.0 | 5.0 | 1.5 | **3.5** | **R** | |
| AVERAGE | | 2.8 | 1.5 | 4.8 | 3.0 | 3.3 | 1.5 | 4.0 | 2.9 | R/Y | D | 3.0 | 3.8 | 2.8 | 3.2 | R/Y | D | 3.0 | 3.8 | 1.8 | 2.8 | R/Y | D | 3.0 | 4.5 | 1.8 | 3.1 | R/Y | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 23 WCA-2B | 28.0 | 5.0 | 4.5 | 5.0 | 4.8 | 2.5 | 4.5 | 1.0 | 2.7 | R | F | 2.5 | 3.0 | 3.0 | 2.8 | R | F | 2.5 | 1.5 | 3.0 | 2.3 | R | F | 2.5 | 1.5 | 3.0 | 2.3 | R | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 20 NW WCA-3A | 23.0 | 5.0 | 5.0 | 5.0 | **5.0** | 2.5 | 1.5 | 2.5 | **2.2** | **G** | | 2.5 | 1.5 | 2.5 | **2.2** | **G** | | 2.5 | 3.5 | 2.5 | **2.8** | **G** | | 2.5 | 3.5 | 2.5 | **2.8** | **G** | |
| 22 NW Corner WCA-3A | 23.0 | 3.0 | 3.0 | 5.0 | **3.7** | 3.0 | 3.0 | 2.5 | **2.8** | **G** | | 3.0 | 3.0 | 4.0 | **3.3** | **G** | | 3.0 | 3.0 | 1.0 | **2.3** | **G** | | 3.0 | 3.0 | 2.5 | **2.8** | **G** | |
| AVERAGE | | 4.0 | 4.0 | 5.0 | 4.3 | 2.8 | 2.3 | 2.5 | 2.5 | G | B | 2.8 | 2.3 | 3.3 | 2.8 | G | B | 2.8 | 3.3 | 1.8 | 2.6 | G | B | 2.8 | 3.3 | 2.5 | 2.8 | G | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 21 NE WCA-3A | 5.0 | 4.0 | 2.0 | 3.0 | 3.0 | 5.0 | 1.0 | 1.0 | 2.3 | G | B | 1.5 | 3.0 | 5.0 | 3.2 | Y | C | 3.0 | 4.5 | 3.0 | 3.5 | R | F | 1.5 | 4.5 | 3.0 | 3.0 | R | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 19 East WCA-3A | 29.0 | 3.0 | 3.0 | 4.0 | 3.3 | 2.0 | 3.0 | 2.0 | 2.3 | R | F | 1.0 | 3.0 | 5.0 | 3.0 | R | F | 5.0 | 3.0 | 2.0 | 3.3 | R | F | 4.0 | 3.0 | 2.0 | 3.0 | R | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 14 South WCA-3A | 36.0 | 1.5 | 3.5 | 3.5 | **2.8** | 1.5 | 3.5 | 5.0 | **3.3** | **Y** | | 4.0 | 1.0 | 3.5 | **2.8** | **G** | | 5.0 | 3.5 | 1.5 | **3.3** | **Y** | | 3.0 | 3.5 | 1.5 | **2.7** | **Y** | |
| 17 South Central WCA-3A | 36.0 | 1.5 | 4.5 | 4.5 | **3.5** | 1.5 | 2.5 | 4.5 | **2.8** | **G** | | 4.0 | 1.0 | 3.0 | **2.7** | **G** | | 5.0 | 2.5 | 1.5 | **3.0** | **Y** | | 3.0 | 4.5 | 1.5 | **3.0** | **Y** | |
| 18 North Central WCA-3A | 36.0 | 1.5 | 2.5 | 5.0 | **3.0** | 1.5 | 1.0 | 4.0 | **2.2** | **G** | | 4.0 | 2.5 | 3.0 | **3.2** | **Y** | | 4.0 | 4.0 | 1.5 | **3.2** | **R** | | 4.0 | 5.0 | 1.5 | **3.5** | **R** | |
| AVERAGE | | 1.5 | 3.5 | 4.3 | 3.1 | 1.5 | 2.3 | 4.5 | 2.8 | G/Y | B | 4.0 | 1.5 | 3.2 | 2.9 | G/Y | B | 4.7 | 3.3 | 1.5 | 3.2 | R/Y | D | 3.3 | 4.3 | 1.5 | 3.1 | R/Y | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 15 West WCA-3B | 13.5 | 1.0 | 2.0 | 5.0 | **2.7** | 2.0 | 1.0 | 1.0 | **1.3** | **G** | | 3.0 | 4.5 | 4.0 | **3.8** | **R** | | 4.0 | 3.0 | 3.0 | **3.3** | **R** | | 5.0 | 4.5 | 2.0 | **3.8** | **R** | |
| 16 East WCA-3B | 13.5 | 4.0 | 3.0 | 4.0 | **3.7** | 1.0 | 1.0 | 1.5 | **1.2** | **G** | | 2.0 | 5.0 | 4.0 | **3.7** | **R** | | 3.0 | 3.0 | 4.0 | **3.3** | **R** | | 5.0 | 3.0 | 1.5 | **3.2** | **R** | |
| AVERAGE | | 2.5 | 2.5 | 4.5 | 3.2 | 1.5 | 1.0 | 1.3 | 1.3 | G | A | 2.5 | 4.8 | 4.0 | 3.8 | R | F | 3.5 | 3.0 | 3.5 | 3.3 | R | F | 5.0 | 3.8 | 1.8 | 3.5 | R | |
| | | In | Hi | Lo | AVE | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | Grade | In | Hi | Lo | AVE | Color | G |
| 52 Pennsuco North | 3.5 | 4.0 | 3.0 | 5.0 | **4.0** | 1.0 | 3.0 | 3.5 | **2.5** | | | 2.5 | 3.0 | 3.5 | **3.0** | | | 2.5 | 3.0 | 2.0 | **2.5** | | | 5.0 | 3.0 | 1.0 | **3.0** | | |
| 53 Pennsuco South | 3.5 | 4.0 | 3.0 | 3.0 | **3.3** | 4.0 | 3.0 | 3.0 | **3.3** | | | 4.0 | 3.0 | 3.0 | **3.3** | | | 2.0 | 3.0 | 3.0 | **2.7** | | | 1.0 | 3.0 | 3.0 | **2.3** | | |
| AVERAGE | | 4.0 | 3.0 | 4.0 | 3.7 | 2.5 | 3.0 | 3.3 | 2.9 | Y | C | 3.3 | 3.0 | 3.3 | 3.2 | Y | C | 2.3 | 3.0 | 2.5 | 2.6 | Y | C | 3.0 | 3.0 | 2.0 | 2.7 | G | |

## F. Southern Everglades, Florida Bay, Model Lands and C-111 Subteam

Shark River Slough

Three priority performance measures for the ecological restoration of Shark River Slough are identified in the Everglades Sloughs Conceptual Model. Those measures, in order of priority, are the duration of uninterrupted flooding, drought severity as measured by the duration of dry conditions, and the water depth during periods of flooding. Two additional performance measures that are considered in Shark River Slough analyses are the total annual flow volume and the seasonal distribution of that flow in mid Shark River Slough.

NSM45F characterized Shark River Slough as a predominantly aquatic system that was continually flooded and flowing during wet and dry seasons and during wet years and all but the most extreme dry years. NSM45F indicated that Shark River Slough would have dried only two, three and six times during the 31-year period of record in the NE, Mid and SW indicator regions, yielding uninterrupted periods of inundation that averaged 535, 401 and 226 weeks. Water depths averaged 1.8, 1.6 and 1.2 feet during periods of flooding in the three respective indicator regions. Dry conditions lasted for an average of four, three and six weeks respectively.

The 1995 Base (Revised) indicated severely over-drained conditions in Shark River Slough. The average duration of uninterrupted flooding was reduced to 74, 99 and 79 weeks in NE, Mid and SW Shark River Slough becaause the marsh dried 18, 14 and 17 times during the period of record. Water depths averaged approximately one foot during periods of flooding. Dry conditions lasted for an average of 11, 10 and 11 weeks, respectively. Total annual overland flow volume down mid Shark River Slough was 44% of that indicated by NSM45F. The seasonal distribution of that flow volume indicated a much higher proportion of the annual flow during the wet season months of July and August and a much lower proportion during the dry season months of December-February in comparison to NSM45F.

The 2050 Base (Revised) showed a slight improvement over the 1995 Base, although over-drained conditions remained in Shark River Slough. The average duration of uninterrupted flooding increased slightly to 79, 108 and 105 weeks in NE, Mid and SW Shark River Slough because the marsh dried 17, 13 and 13 times during the period of record. Water depths continued to average approximately one foot during periods of flooding. Dry conditions lasted for an average of 11, 8 and 11 weeks, respectively. Total annual overland flow volume down mid Shark River Slough increased to 52% of that indicated by NSM45F. The seasonal distribution of that flow volume indicated a higher proportion of the annual flow during the wet season months of August-October and a lower proportion during the dry season months of December-February in comparison to NSM45F.

Alternatives A-D represented improvement over the over-drained base conditions in Shark River Slough, and Alternative D demonstrated a markedly higher level of achievement of performance measures compared to Alternatives A-C. Alternative D increased the average duration of uninterrupted flooding to 263, 317 and 173 weeks in NE, Mid and SW Shark River Slough by reducing the number of drydowns to five, four and eight events respectively during the period of record. Average water depth during periods of flooding increased slightly to 1.3 feet in NE and Mid Shark River Slough. The duration of dry conditions was reduced to six-seven weeks in all three indicator regions. Total annual overland flow volume down mid Shark River Slough was increased to 66% of that indicated by NSM45F. The seasonal distribution of that flow volume more closely resembled that of NSM45F, although a slightly higher proportion occurred during May-June, and a slightly lower proportion occurred during November-January.

Although Alternative D was substantially improved over the base conditions, it fell considerably short of the performance targets for Shark River Slough when performance was averaged over the three indicator regions. Relative to NSM45F, the duration of uninterrupted flooding in Alternative D was 53-272 weeks shorter in the three indicator regions, yielding an achievement index for the Slough as a whole of 68% compared to 25% for 1995 Base and 29% for 2050 Base. The deficiency in duration of uninterrupted flooding was due to five dry events over the period of record in Alternative D compared to two in NSM45F. The mean water depth during periods of flooding in Alternative D was deficient by 0.3-0.5 feet compared to NSM45F in the three indicator regions, yielding an achievement index for the entire Slough of 79% compared to 58% for 1995 Base and 67% for 2050 Base. Dry periods in NE and Mid Shark River Slough averaged three weeks longer in Alternative D than the 3-4 week duration indicated by NSM45F. The extended duration of dry conditions lowered the achievement index for that performance measure to 36% for the Slough as a whole. Total annual overland flow volume down mid Shark River Slough in Alternative D, which was 66% of the NSM45F flow volume, yielded an achievement index of 66% compared to 44% for 1995 Base and 52% for 2050 Base. The seasonal distribution of the annual flow volume down mid Shark River Slough, expressed as percent of the annual flow volume during each month of the year, provided a 90% match in Alternative D compared to NSM45F and yielded an achievement index of 90% compared to 76% for 1995 Base and 88% for 2050 Base.

The overall achievement index for the performance measures in Shark River Slough under Alternative D was 64% compared to 16% for 1995 Base and 26% for 2050 Base. The overall score was calculated by averaging the five performance measures over the three indicator regions with weightings of three for duration of flooding, two for duration of dry conditions, and one each for mean depth during flooding, annual overland flow volume and seasonal flow distribution. A 0.6 achievement of the hydrologic performance measures does not provide adequate assurance that the ecological values identified in the Everglades Sloughs Conceptual Model would be restored under Alternative D in Shark River Slough. Furthermore, Alternative D only partially restores hydrological and ecological connectivity of Shark River Slough in Everglades National Park to its upstream reaches in Water Conservation Area 3A due to the presence of western levee L-29. Reasonable assurance that ecological values will be restored in Shark River Slough depends on attaining an achievement index approaching 0.8 for the combined performance measures. Of particular concern is the mean duration of uninterrupted flooding as affected by the number of drydowns during the period of record. Confidence in the restoration of ecological values in Shark River Slough furthermore depends on increasing connectivity between the Park and Water Conservation Area 3, as was attempted in Alternative B.

Rockland Marl Marsh

Three priority hydrologic performance measures for the ecological restoration of the Rockland Marl Marsh are identified in the Marl Prairie/Rocky Glades Conceptual Model. Those measures, in order of priority, are the duration of uninterrupted flooding, drought severity as measured by the duration of dry conditions, and the number of wet season water level reversals when the depth drops to less than 0.2 feet during a period of flooding.

NSM45F characterized the Rockland Marl Marsh as a seasonally flooded system where water levels typically dropped below the ground surface during most years, except during prolonged high rainfall periods when the marsh remained flooded for multiple years. NSM45F indicated that uninterrupted periods of inundation averaged 44 weeks. Only two wet season water level reversals occurred during 31 years. Dry conditions lasted for an average of 26 weeks.

The 1995 Base (Revised) indicated severely over-drained conditions in the Rockland Marl Marsh. The average duration of uninterrupted flooding was reduced to 12 weeks. Thirty-one wet season water level reversals occurred during 31 years. Dry conditions lasted for an average of 45 weeks.

The 2050 Base (Revised) improved conditions in the Rockland Marl Marsh, but performance still fell far short of NSM45F targets. The average duration of uninterrupted flooding was nearly doubled to 23 weeks. The number of wet season water level reversals was reduced to 18 in 31 years. The duration of dry conditions was reduced to an average of 31 weeks.

Alternatives A-D all represented improvement over the over-drained base conditions in the Rockland Marl Marsh, and Alternative D was the most successful in achieving restoration targets. The average duration of uninterrupted flooding increased to 32 weeks. The number of wet season water level reversals was reduced to three in 31 years. Dry conditions lasted for an average of 24 weeks.

Performance of Alternative D came close to achieving the restoration targets for the Rockland Marl Marsh. The mean duration of uninterrupted flooding, which was 12 weeks short of the NSM45F target, scored an achievement index of 73% compared to 27% for 1995 Base and 52% for 2050 Base. The number of wet season water level reversals exceeded NSM45F by only one and yielded an achievement index of 96%. The mean duration of dry conditions was two weeks shorter than NSM45F and thus over-achieved the target by 8%, yielding an achievement index of 92% compared to 27% for 1995 Base and 81% for 2050 Base.

The overall achievement index for the performance measures in the Rockland Marl Marsh under Alternative D was 83% compared to 22% for 1995 Base and 60% for 2050 Base. This score was calculated by averaging the three performance measures with weightings of three for duration of flooding, two for duration of dry conditions, and one for number of wet season water level reversals. A 0.8 achievement of the hydrologic performance measures is considered to provide reasonable assurance that ecological values identified in the Marl Preairie/Rocky Glades Conceptual Model would be restored under Alternative D in the Rockland Marl Marsh.

Florida Bay Coastal Basins

Four priority performance measures for the ecological restoration of the Florida Bay coastal basins are identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model. All performance measures are based on relationships between mean monthly salinity in five coastal basins, from Joe Bay to North River Mouth, to water stage at the P33 gage in mid Shark River Slough.

One measure is the number of months during the period of record when stages equal or exceed 6.3 feet msl at P33. Stages above 6.3 at P33 correspond to a reduced frequency of undesirable high salinity events in the coastal basins. A second measure is the number of months during the period of record when stages equal or exceed 7.3 feet msl at the P33 gage. Stages above 7.3 at P33 correspond to an increased frequency of desirable low salinity events in the coastal basins. The reduced frequency of undesirable high salinity events when the P33 stage reaches 6.3 is given a higher priority than the increased frequency of desirable low salinity events when the P33 stage reaches 7.3.

A third measure is the cumulative salinity difference (ppt) from the undesirable high salinity levels that were identified for each basin. Cumulative differences from high salinity levels are summed during the dry/wet season transition months of March-June. A fourth measure is the cumulative salinity difference (ppt) from desirable low salinity levels that were identified for each basin. Cumulative differences from low salinity levels are summed during the wet/dry season months of August-October. These differences are summed over the five coastal basins and over the 31-year period of record. Differences above the specified high or low salinity levels are given a positive value, and differences below the specified high or low salinity levels are given a negative value. The performance targets are to reduce cumulative salinity differences to values that do not exceed the cumulative differences produced by NSM45F.

NSM45F characterized the Florida Bay coastal basins as estuarine environments that experienced low to moderate salinity well below seawater concentrations the majority of the time. The coastal basins would have avoided high salinity events, (>15 to >35 ppt depending on the basin) during 258 months of the 372-month period of record when P33 stages rose to 6.3. Low salinity events (<5 to <25 ppt, depending on the basin) would have occurred during 30 months of the period of record when P33 stages rose to 7.3. The cumulative salinity difference from concentrations that marked high salinity events during March-June totaled 440 ppt over the five basins and 31 years, while the cumulative salinity difference from concentrations that marked low salinity events during August-October totaled 525 ppt.

The 1995 Base (Revised) indicated a prevalence of high salinity conditions and a paucity of low salinity events that shifted the the estuarine environments of the coastal basins to more marine conditions. The coastal basins experienced high salinity events during two-thirds of the period of record, when P33 stages fell below 6.3 for 247 out of 372 months. Low salinity events occurred only during seven of the 372 months. The cumulative salinity difference from concentrations that marked high salinity events during March-June totaled 2755 ppt, while the cumulative difference from concentrations that marked low salinity events during August-October totaled 1765 ppt.

The 2050 Base (Revised) showed only slight improvement over 1995 Base in salinity regimes in the coastal basins. High salinity events were less frequent and occurred during 195 out of 372 months, but low salinity events were also less frequent and only occurred during two out of 372 months. Cumulative salinity differences from concentrations that marked high and low salinity events during the periods of March-June and August to October were slightly reduced to 2515 and 1545 ppt, respectively.

Alternatives A-D all substantially improved salinity regimes in the coastal basins, and each alternative was approximately equally effective in overall performance. Alternative D decreased the number of high salinity events to 164 months and avoided high salinity events during 208 months of the 372-month period of record. Alternative D increased the number of low salinity events to 25 during the period of record. The cumulative salinity difference from concentrations that marked high salinity events during March-June totaled 735 ppt, while the cumulative salinity difference from concentrations that marked low salinity events during August-October totaled 1155 ppt.

Performance of Alternative D approached restoration targets for the Florida Bay coastal basins for three of the four performance measures. The number of months when P33 stages rose to 6.3 was 81% of NSM45F compared to 48% for 1995 Base and 69% for 2050 Base. The months when P33 stages rose to 7.3 was 83% of NSM45F compared to 23% for 1995 Base and 7% for 2050 Base. The cumulative salinity difference from concentrations that marked high salinity events during March-June scored an achievement index of 87%, but the cumulative salinity difference from concentrations that marked low salinity events during August-October scored an achievement index of only 49%, both relative to an NSM45F score of 100%.

The overall achievement index for the performance measures in the Florida Bay coastal basins under Alternative D was 78% compared to 20% for 1995 Base and 30% for 2050 Base. A similar achievement index, rounded off to 0.8, was also attained for Alternatives A-C. These scores were calculated from the four performance measures with weightings of two for the number of months when stages equaled or exceeded 6.3 at P33, one for the number of months when stages equaled or exceeded 7.3 at P33, two for cumulative salinity differences from undesirable high levels during March-June, and one for cumulative salinity differences from desirable low levels during August-October. A 0.8 achievement of the hydrology/salinity performance measures is considered to provide reasonable assurance that the ecological values identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model would be restored under Alternative D in the Florida Bay coastal basins.

**SOUTHERN EVERGLADES: INDICATOR REGIONS**

| WET CONDITIONS | | | DRY CONDITIONS | | REVERSALS |
|---|---|---|---|---|---|
| Tot # Weeks | Mean # Weeks | Depth Feet | # Dry Events | Mean # Weeks | # of Wet Season Depth Reversals |

**NE Shark River Slough Indicator Region 11**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NSM45 | | 1604 | 535 | 1.8 | | 2 | 4 |
| 95BSR | 1406 | 74 | 0.8 | | 18 | 11 | |
| 50BSR | 1423 | 79 | 1.0 | | 17 | 11 | |
| ALT A | 1546 | 119 | 1.3 | | 12 | 6 | |
| ALT B | 1567 | 196 | 1.3 | | 7 | 6 | |
| ALT C | 1559 | 195 | 1.3 | | 7 | 8 | |
| ALT D | 1579 | 263 | 1.3 | | 5 | 7 | |

**Mid Shark River Slough Indicator Region 10**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NSM45 | | 1602 | 401 | 1.6 | | 3 | 3 |
| 95BSR | 1479 | 99 | 1.0 | | 14 | 10 | |
| 50BSR | 1505 | 108 | 1.1 | | 13 | 8 | |
| ALT A | 1547 | 172 | 1.3 | | 8 | 8 | |
| ALT B | 1579 | 197 | 1.2 | | 7 | 5 | |
| ALT C | 1579 | 226 | 1.2 | | 6 | 6 | |
| ALT D | 1586 | 317 | 1.3 | | 4 | 6 | |

**SW Shark River Slough Indicator Region 9**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NSM45 | | 1578 | 226 | 1.2 | | 6 | 6 |
| 95BSR | 1426 | 79 | 0.8 | | 17 | 11 | |
| 50BSR | 1469 | 105 | 0.9 | | 13 | 11 | |
| ALT A | 1516 | 168 | 1.1 | | 8 | 12 | |
| ALT B | 1535 | 154 | 1.0 | | 9 | 9 | |
| ALT C | 1546 | 155 | 0.9 | | 9 | 7 | |
| ALT D | 1556 | 173 | 1.0 | | 8 | 7 | |

Rockland Marl Marsh Indicator Region 8

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| NSM45 | | 1019 | 44 | 0.6 | | 23 | 26 | | 2 |
| 95BSR | 341 | 12 | 0.3 | | 28 | 45 | | 31 | |
| 50BSR | 692 | 23 | 0.5 | | 30 | 31 | | 18 | |
| ALT A | 953 | 30 | 0.6 | | 32 | 21 | | 12 | |
| ALT B | 935 | 29 | 0.5 | | 32 | 21 | | 17 | |
| ALT C | 887 | 31 | 0.5 | | 29 | 25 | | 15 | |
| ALT D | 920 | 32 | 0.6 | | 29 | 24 | | 3 | |

Cape Sable Sparrow E Indicator Region 57

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NSM45 | | 744 | 24 | 0.3 | | 31 | 28 |
| 95BSR | 331 | 13 | 0.3 | | 25 | 51 | |
| 50BSR | 513 | 18 | 0.3 | | 28 | 39 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ALT A | 740 | 26 | 0.4 | 29 | 30 | |
| ALT B | 748 | 24 | 0.4 | 31 | 28 | |
| ALT C | 686 | 24 | 0.3 | 28 | 33 | |
| ALT D | 718 | 24 | 0.3 | 30 | 30 | |

Cape Sable Sparrow A Indicator Region 46

| | | | | | | |
|---|---|---|---|---|---|---|
| NSM45 | 1080 | 36 | 0.4 | | 30 | 18 |
| 95BSR | 985 | 35 | 0.4 | 28 | 22 | |
| 50BSR | 1135 | 40 | 0.4 | 28 | 17 | |
| ALT A | 1023 | 38 | 0.4 | 27 | 22 | |
| ALT B | 954 | 34 | 0.4 | 28 | 24 | |
| ALT C | 1044 | 36 | 0.4 | 29 | 20 | |
| ALT D | 1041 | 37 | 0.4 | 28 | 20 | |

Cape Sable Sparrow B Indicator Region 54

| | | | | | | |
|---|---|---|---|---|---|---|
| NSM45 | 551 | 15 | 0.3 | | 37 | 29 |
| 95BSR | 558 | 15 | 0.3 | 39 | 27 | |
| 50BSR | 560 | 14 | 0.3 | 40 | 26 | |
| ALT A | 582 | 15 | 0.3 | 38 | 27 | |
| ALT B | 579 | 15 | 0.3 | 38 | 27 | |
| ALT C | 572 | 15 | 0.3 | 38 | 27 | |
| ALT D | 574 | 15 | 0.3 | 39 | 27 | |

SOUTHERN EVERGLADES: P33/COASTAL BASIN SALINITY RELATIONSHIPS

NUMBER OF MONTHS THAT P33 STAGE IS EQUALLED OR EXCEEDED

| | 6.3 Feet MSL | 7.3 Feet MSL |
|---|---|---|
| NSM45 | 258 | 30 |
| 95BSR | 125 | 7 |
| 50BSR | 177 | 2 |
| ALT A | 226 | 24 |
| ALT B | 204 | 28 |
| ALT C | 204 | 22 |
| ALT D | 208 | 25 |

CUMULATIVE SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS FOR NORTH RIVER, GARFIELD BIGHT, TERRAPIN BAY AND JOE BAY

| | MAR-JUN | AUG-OCT |
|---|---|---|
| NSM45 | 440 | 525 |
| 95BSR | 2755 | 1765 |
| 50BSR | 2515 | 1545 |
| ALT A | 1005 | 625 |
| ALT B | 670 | 800 |
| ALT C | 665 | 930 |
| ALT D | 735 | 1155 |

**SOUTHERN EVERGLADES: ACHIEVEMENT INDEX OF PERFORMANCE MEASURES RELATIVE TO NSM45F WITH A VALUE OF 100**

SHARK RIVER SLOUGH

| | MEAN DURATION OF UNINTERRUPTED FLOODING, INDICATOR REGIONS 9, 10 AND 11 (WT = 3) | MEAN DURATION OF DRY CONDITIONS, INDICATOR REGIONS 9, 10 AND 11 (WT = 2) | MEAN DEPTH DURING FLOODING INDICATOR REGIONS 9, 10 AND 11 (WT = 1) |
|---|---|---|---|
| 95BSR | 25 | -64 | 58 |
| 50BSR | 29 | -42 | 67 |
| ALT A | 46 | -6 | 82 |
| ALT B | 51 | 44 | 77 |
| ALT C | 53 | 28 | 74 |
| ALT D | 68 | 36 | 79 |

| | CENTRAL SHARK RIVER SLOUGH ANNUAL OVERLAND FLOW VOLUME (WT = 1) | CENTRAL SHARK RIVER SLOUGH CUMULATIVE DEVIATION FROM MONTHLY FLOW VALUES (WT = 1) |
|---|---|---|
| 95BSR | 44 | 76 |
| 50BSR | 52 | 88 |
| ALT A | 80 | 92 |
| ALT B | 72 | 92 |

| | | |
|---|---|---|
| ALT C | 64 | 90 |
| ALT D | 66 | 90 |

ROCKLAND MARL MARSH INDICATOR REGION 8

| | MEAN DURATION OF UNINTERRUPTED FLOODING (WT = 3) | MEAN DURATION OF DRY CONDITIONS (WT = 2) | # OF WET SEASON DEPTH REVERSALS (WT = 1) |
|---|---|---|---|
| 95BSR | 27 | 27 | 0 |
| 50BSR | 52 | 81 | 45 |
| ALT A | 68 | 81 | 65 |
| ALT B | 66 | 81 | 48 |
| ALT C | 70 | 96 | 55 |
| ALT D | 73 | 92 | 96 |

FLORIDA BAY COASTAL BASIN SALINITY/GAGE P33 STAGE

| | # OF MONTHS WHEN P33 STAGE OF 6.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 2) | # OF MONTHS WHEN P33 STAGE OF 7.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 1) |
|---|---|---|
| 95BSR | 48 | 23 |
| 50BSR | 69 | 7 |
| ALT A | 87 | 80 |
| ALT B | 79 | 93 |
| ALT C | 79 | 73 |
| ALT D | 81 | 83 |

| | CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS MARCH – JUNE (WT = 2) | CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS AUGUST - OCTOBER (WT = 1) |
|---|---|---|
| 95BSR | 0 | 0 |
| 50BSR | 10 | 18 |
| ALT A | 76 | 92 |
| ALT B | 90 | 78 |
| ALT C | 90 | 67 |
| ALT D | 87 | 49 |

SOUTHERN EVERGLADES
WEIGHTED MEAN ACHIEVEMENT INDEX OF PERFORMANCE MEASURES

| | SHARK RIVER SLOUGH | ROCKLAND MARL MARSH | FLORIDA BAY COASTAL BASINS/P33 |
|---|---|---|---|
| 95BSR | 16 | 22 | 20 |
| 50BSR | 26 | 60 | 30 |
| ALT A | 48 | 72 | 83 |
| ALT B | 60 | 68 | 85 |
| ALT C | 55 | 76 | 80 |
| ALT D | 64 | 83 | 78 |

**Alternative D13R**

Performance measures for the evaluation Alternative D13R in the southern Everglades were the same as those used to evaluate Alternative D, with one exception. The mean duration of dry conditions, that was used as a measure of drought severity in Shark River Slough for Alternative D, was replaced by the number of dry events during the period of record for Alternative D13R. That change was made because Alternative D13R was successful in achieving its priority goal of reducing the number of dry events in order to increase the mean duration of uninterrupted flooding. However, the dry events that were eliminated were those of shorter duration, and the longer dry events that remained represented major regional droughts when little could be done to keep Shark River Slough flooded. Thus achieving the goal of reducing the number of dry events would have penalized D13R for increasing the mean duration of dry conditions, when actually the duration of the remaining droughts in D13R was similar to that in Alternative D. Since reduction in the number of dry events became a priority for Shark River Slough in the modeling leading to Alternative D13R, it was added as a performance measure to replace mean duration of flooding.

**Shark River Slough**

Alternative D13R was successful in reducing the number of dry events during the period of record in order to closely approach the frequency indicated by NSM45F for Shark River Slough. The reduction in the number of dry events in NE, Mid and SW Shark River Slough from 18, 14 and 17 under 19 95BaseR and 17, 13 and 13 under 2050 Base to three, four and eight under D13R, with targets of two, three and six under NSM45F. This reduction represented an 89% achievement of the NSM45F restoration target for the Slough as a whole.

Somewhat less success was realized in increasing the prolonged mean duration of uninterrupted flooding indicated by NSM45F in Shark River Slough because of the extra one to two dry events in Alternative D13R. Alternative D13R increased the mean duration of flooding in NE, Mid and SW Shark River Slough from 74, 99 and 79 weeks under 1995 Base and 79, 108 and 105 weeks under 2050 Base to 395, 318 and 173 weeks. However, mean the mean duration of uninterrupted flooding in Alternative D13R fell short NSM45F values of 535, 401 and 226 weeks for the three indicator regions The increase in mean duration of uninterrupted flooding in

NE, Mid and SW Shark River Slough achieved 76% of the NSM45F restoration target for the Slough as a whole, compared to 25% achievement under 1995 Base and 29% under 2050 Base.

Alternative D13R increased the mean water depth during periods of flooding in NE, Mid and SW Shark River Slough from 0.8, 1.0 and 0.8 feet under 1995 Base and 1.0, 1.1 and 0.9 feet under 2050 Base to 1.4, 1.2 and 1.0 feet. NSM45F values were 1.8, 1.6 and 1.2 feet for the three indicator regions. Alternative D13R mean depths during flooding achieved 79% of the NSM45F restoration target for the Slough as a whole, compared to 58% achievement under 1995 Base and 67% under 2050 Base.

Total annual overland flow volume down mid Shark River Slough in Alternative D13R was 70% of that indicated by NSM45F in comparison to 44% under 1995 Base and 52% under 2050 Base. The seasonal distribution of that flow volume, expressed as percent of the annual flow volume during each month of the year, provided a 91% match to NSM45F in Alternative D13R in comparison to a 76% match under 1995 Base and 88% under 2050 Base.

The overall achievement index for the performance measures in Shark River Slough under Alternative D13R was 82% compared to 28% under 1995 Base and 38% under 2050 Base. This score was calculated by averaging the five performance measures over the three indicator regions with weightings of three each for duration of flooding and number of dry events and weightings of one each for mean depth during flooding, annual overland flow volume and seasonal flow distribution. A 0.8 achievement of the hydrologic performance measures is considered to provide reasonable assurance that the ecological values identified in the Everglades Sloughs Conceptual Model would be restored under Alternative D13R in Shark River Slough. Confidence in the restoration of ecological values in Shark River Slough is further increased by the increased connectivity between the Slough in Everglades National Park and its upper reaches in Water Conservation Area 3 due to the removal of L-29 in Alternative D13R.

Ecological values and indicators of restoration success in Shark River Slough that are linked to the above hydrologic performance measures in the conceptual model include 1) increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased abundance of wading birds and wood storks, 4) re-establishment of coastal nesting colonies of wading birds and wood storks, 5) earlier timing of colony formation by wading birds and wood storks, 6) resumption of the return frequency of wading bird and white ibis super colonies, 7) enhanced production and community composition of periphyton, 8) accelerated accretion of peat soils, and 9) persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs.

**Rockland Marl Marsh**

Alternative D13R prolonged the mean duration of uninterrupted flooding in the Rockland Marl Marsh from 12 weeks under 1995 Base and 23 weeks under 2050 Base to 30 weeks, in comparison to the NSM45F duration of 44 weeks. The increase in mean duration of uninterrupted flooding in the Rockland Marl Marsh achieved 68% of the NSM45F restoration target compared to 27% achievement under 1995 Base and 52% under 2050 Base.

The number of wet season water level reversals during the 31-year period of record in the Rockland Marl Marsh was reduced to four under Alternative D13R in comparison to 31 under 1995 Base, 18 under 2050 Base and two under NSM45F. The reduction in the number of reversals represented a 93% achievement of the NSM45F restoration target for the Rockland Marl Marsh.

Dry conditions in the Rockland Marl Marsh lasted for an average duration of 21 weeks under Alternative D13R in comparison to 45 weeks under 1995 Base, 31 weeks under 2050 Base and 26 weeks under NSM45F. The reduction in the mean duration of dry conditions in alternative D13R actually overshot NSM45F by 19% and achieved 81% of the NSM45F restoration target for the Rockland Marl Marsh, compared to 27% achievement under 1995 Base and 81% under 2050 Base.

The overall achievement index for the performance measures in the Rockland Marl Marsh was 76% compared to 22% achievement under 1995 Base and 60% under 2050 Base. This score was calculated by averaging the three performance measures with weightings of three for duration of flooding, two for duration of dry conditions, and one for number of wet season water level reversals. A 0.8 achievement of the hydrologic performance measures is considered to provide reasonable assurance that ecological values identified in the Marl Prairie/Rocky Glades Conceptual Model would be restored under Alternative D13R in the Rockland Marl Marsh.

Ecological values and indicators of restoration success in the Rockland Marl Marsh that are linked to the above hydrologic performance measures in the conceptual model include 1) re-colonization and population resurgence by American alligators and a subsequent increase in the number of occupied alligator holes to serve as dry season refugia for aquatic fauna and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased seasonal abundance and foraging activity of wading birds and wood storks, 4) enhanced production and community composition of periphyton, 5) accelerated accretion of marl substrate, 6) increased nesting success and population size of Cape Sable seaside sparrows, and 7) persistence and resilience of highly diverse macrophyte and tree island plant communities.

**Florida Bay Coastal Basins**

Alternative D13R was successful in avoiding high salinity events (>15 to >35 ppt, depending on the basin) in the Florida Bay coastal basins during 228 months of the 372-month period of record when P33 stages rose to 6.3 feet msl. In comparison, high salinity events were avoided during 258 months under NSM45F, 125 months under 1995 Base, and 177 months under 2050 Base. The reduction in the number of high salinity events achieved 88% of the NSM45F restoration target under Alternative D13R compared to 48% achievement under 1995 Base and 69% under 2050 Base.

Alternative D13R was successful in attaining low salinity events (<5 to <15 ppt, depending on the basin) in the Florida Bay coastal basins during 18 months of the period of record when P33 stages rose to 7.3 feet msl. Low salinity events were attained during 30 months under NSM45F, seven months under 1995 Base, and only two months under 2050 Base.

The increase in the number of low salinity events achieved 60% of the NSM45F restoration target under Alternative D13R compared to 23% achievement under 1995 Base and 7% under 2050 Base.

The cumulative salinity difference from concentrations that marked high salinity events during March-June decreased from 2755 ppt under 1995 Base and 2515 ppt under 2050 Base to 660 ppt under Alternative D13R. The NSM45F target was 440 ppt. The reduction in the March-June cumulative salinity difference represented a 91% achievement of the NSM45F restoration target for the Florida Bay coastal basins.

The cumulative salinity difference from concentrations that marked low salinity events during August-October decreased from 1765 ppt under 1995 Base and 1545 ppt under 2050 Base to 1025 ppt under Alternative D13R. The NSM45F target was 525 ppt. The reduction in the August-October cumulative difference represented a 60% achievement on the NSM45F restoration target for the Florida Bay coastal basins.

The overall achievement index for the performance measures in the Florida Bay coastal basins under Alternative D13R was 80% compared to 20% for 1995 Base and 50% for 2050 Base. These scores were calculated from the four performance measures with weightings of two for the number of months when stages equaled or exceeded 6.3 at P33, one for the number of months when stages equaled or exceeded 7.3 at P33, two for cumulative salinity differences from undesirable high levels during March-June, and one for cumulative salinity differences from desirable low levels during August-October. A 0.8 achievement of the hydrology/salinity performance measures is considered to provide reasonable assurance that the ecological values identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model would be restored under Alternative D13R in the Florida Bay coastal basins.

Ecological values and indicators of restoration success in the Florida Bay mangrove estuary and coastal basins that are linked to the above hydrology/salinity performance measures in the conceptual model include 1) increased production of low-salinity mangrove fish and invertebrates, 2) re-establishment of coastal nesting colonies of wading birds and wood storks and eastern Florida Bay colonies of roseate spoonbill, 3) earlier timing of coastal colony formation by wading birds and wood storks, 4) resumption of the return frequency of wading bird and white ibis super colonies, 5) increased growth and survival of juvenile American crocodiles, 6) increased cover of low-to-moderate salinity aquatic macrophyte communities in coastal lakes and basins, 7) return of seasonal waterfowl aggregations to coastal lakes and basins, 8) enhanced nursery ground value for sport fishes and pink shrimp in coastal basins, and 9) persistence and resilience of the mangrove, salt marsh and tidal creek vegetation mosaic.

## SOUTHERN EVERGLADES: INDICATOR REGIONS

| | WET CONDITIONS | | | | DRY CONDITIONS | | | REVERSALS | |
|---|---|---|---|---|---|---|---|---|---|
| | Tot # Weeks | Mean # Weeks | Depth Feet | # Dry Events | Mean # Weeks | # of Wet Season Depth Reversals | | | |
| NE Shark River Slough Indicator Region 11 | | | | | | | | | |
| NSM45 | | 1604 | 535 | 1.8 | | 2 | 4 | | |
| 95BSR | 1406 | 74 | 0.8 | | 18 | 11 | | | |
| 50BSR | 1423 | 79 | 1.0 | | 17 | 11 | | | |
| D13R | 1583 | 395 | 1.4 | | 3 | 10 | | | |
| Mid Shark River Slough Indicator Region 10 | | | | | | | | | |
| NSM45 | | 1602 | 401 | 1.6 | | 3 | 3 | | |
| 95BSR | 1479 | 99 | 1.0 | | 14 | 10 | | | |
| 50BSR | 1505 | 108 | 1.1 | | 13 | 8 | | | |
| D13R | 1591 | 318 | 1.2 | | 4 | 5 | | | |
| SW Shark River Slough Indicator Region 9 | | | | | | | | | |
| NSM45 | | 1578 | 226 | 1.2 | | 6 | 6 | | |
| 95BSR | 1426 | 79 | 0.8 | | 17 | 11 | | | |
| 50BSR | 1469 | 105 | 0.9 | | 13 | 11 | | | |
| D13R | 1559 | 173 | 1.0 | | 8 | 7 | | | |
| Rockland Marl Marsh Indicator Region 8 | | | | | | | | | |
| NSM45 | | 1019 | 44 | 0.6 | | 23 | 26 | | 2 |
| 95BSR | 341 | 12 | 0.3 | | 28 | 45 | | 31 | |
| 50BSR | 692 | 23 | 0.5 | | 30 | 31 | | 18 | |
| D13R | 946 | 30 | 0.6 | | 32 | 21 | | 4 | |

SOUTHERN EVERGLADES: P33/COASTAL BASIN SALINITY RELATIONSHIPS

NUMBER OF MONTHS THAT P33 STAGE IS EQUALLED OR EXCEEDED

| | 6.3 Feet MSL | 7.3 Feet MSL |
|---|---|---|
| NSM45 | 258 | 30 |
| 95BSR | 125 | 7 |

| | | |
|---|---|---|
| 50BSR | 177 | 2 |
| D13R | 228 | 18 |

CUMULATIVE SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS FOR NORTH RIVER, GARFIELD BIGHT, TERRAPIN BAY, LITTLE MADEIRA BAY,AND JOE BAY

| | MAR-JUN | AUG-OCT |
|---|---|---|
| NSM45 | 440 | 525 |
| 95BSR | 2755 | 1765 |
| 50BSR | 2515 | 1545 |
| D13R | 660 | 1025 |

**SOUTHERN EVERGLADES ACHIEVEMENT INDEX OF PERFORMANCE MEASURES RELATIVE TO NSM45F WITH A VALUE OF 100**

SHARK RIVER SLOUGH

| | MEAN DURATION OF UNINTERRUPTED FLOODING INDICATOR<br>REGIONS 9, 10 AND 11 (WT = 3) | MEAN NUMBER OF DRY EVENTS, FLOODING, INDICATOR<br>REGIONS 9, 10 AND 11 (WT = 3) | MEAN DEPTH DURING INDICATOR<br>REGIONS 9, 10 AND 11 (WT = 1) |
|---|---|---|---|
| 95BSR | 25 | 0 | 58 |
| 50BSR | 29 | 17 | 67 |
| D13R | 76 | 89 | 79 |

| | CENTRAL SHARK RIVER SLOUGH ANNUAL OVERLAND FLOW VOLUME (WT = 1) | CENTRAL SHARK RIVER SLOUGH CUMULATIVE DEVIATION FROM MONTHLY FLOW VALUES (WT = 1) |
|---|---|---|
| 95BSR | 44 | 76 |
| 50BSR | 52 | 88 |
| D13R | 70 | 91 |

ROCKLAND MARL MARSH INDICATOR REGION 8

| MEAN DURATION OF | MEAN DURATION | # OF WET SEASON |
|---|---|---|

| | UNINTERRUPTED FLOODING (WT = 3) | OF DRY CONDITIONS (WT = 2) | DEPTH REVERSALS (WT = 1) |
|---|---|---|---|
| 95BSR | 27 | 27 | 0 |
| 50BSR | 52 | 81 | 45 |
| D13R | 68 | 81 | 93 |

FLORIDA BAY COASTAL BASIN SALINITY/GAGE P33 STAGE

| | # OF MONTHS WHEN P33 STAGE OF 6.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 2) | # OF MONTHS WHEN P33 STAGE OF 7.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 1) |
|---|---|---|
| 95BSR | 48 | 23 |
| 50BSR | 69 | 7 |
| D13R | 88 | 60 |

| | CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS MARCH – JUNE (WT = 2) | CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS AUGUST - OCTOBER (WT = 1) |
|---|---|---|
| 95BSR | 0 | 0 |
| 50BSR | 10 | 18 |
| D13R | 91 | 60 |

SOUTHERN EVERGLADES

WEIGHTED MEAN ACHIEVEMENT INDEX OF PERFORMANCE MEASURES

| | SHARK RIVER SLOUGH | ROCKLAND MARL MARSH | FLORIDA BAY COASTAL BASINS/P33 |
|---|---|---|---|
| 95BSR | 28 | 22 | 20 |
| 50BSR | 38 | 60 | 30 |
| D13R | 82 | 76 | 80 |

Model Lands-C111 Area Evaluation Matrix

Description of Performance Measures

The Model Lands Alternatives Evaluation Matrix consists of five or six performance indices, which are applied to each of the four indicator regions in the Model Lands area: 4, 5, 6, and 47. Indicator Regions 4 and 47 are located immediately west of US 1 and in proximity to the C-111 Canal. Indicator Regions 5 and 6 are located east of US 1. Initial scores for performance indices 1 through 4 were obtained from stage duration curves. Initial scores for performance indices 5 and 6 were obtained from the data tables supporting the inundation pattern curves. For performance indices 1 through 4, stage durations are examined in relation to specified high and low water depth thresholds, which were based on land elevation and vegetation cover and differ for each indicator region, as follows:

| Indicator Region | Name | High (ft) | Low (ft) |
|---|---|---|---|
| 4 | C111 Perrine Marl Marsh | 2 | 0.5 |
| 5 | Model Lands South | 2 | 0.5 |
| 6 | Model Lands North | 1.75 | 0.25 |
| 47 | C111 North | 1.75 | 0.001 |

Following is a brief description of each performance index.

1. High water index: The proportion of time that water levels are below the high water threshold which has been specified for the indicator region (calculated as [1 - proportion of time water levels are above a specified level]). The target is 1.00, however proportions down to 0.90 are acceptable to allow for interannual variation. This index quantifies the period of time that water levels are so high that they may stress the vegetation communities naturally characteristic of these areas.
2. Low water index: The proportion of time that water levels are above the specified low water threshold. The target is 1.00. This criterion seeks to minimize the period of time that water levels are below a specified low water level.
3. Extreme low water index: The proportion of time that water levels less than 1 ft below the specified low water threshold. Calculated as (1 – proportion of time water levels are >1 ft below the specified low-water threshold). Target is 1.00. Values near 1 indicate that dry season levels are above the extreme low water level almost all of the time. Values closer to 0 indicate that dry season water levels typically fall at least another foot below the specified low water level.
4. Relative dry period slope index: Relative measure of the steepness of the slope of the stage duration curve during dry periods. Calculated as (1-(value for low water index divided by value for extreme low water index)). The index can vary from almost 0 (very steep slope; water levels drop dramatically during dry periods) to approximately 1.0 (slope shallow; water levels relatively stable throughout the dry season). Values closer to one are preferred.
5. Wet Season Inundation Pattern Index: Proportional measure of how many times during the 31-yr simulation that water levels drop below surface elevation during the July-October portion of the wet season. Calculated as (Value for Alternative – Value for Best Alternative) divided by (Value for Worst Alternative – Value for Best Alternative). The best alternative received a score of 1.0 and the worst received a score of 0.0. This criterion gives a relative ranking for how many times the aquatic habitat is disrupted by

drydowns during the core months of the wet season. The months June and November were omitted from the analysis to allow for variation early and late in the season.

6. Dry Season Inundation Pattern Index: Proportional measure of how many times during the 31-yr simulation that water levels rose above surface elevation during the January – May portion of the dry season. (The months November and June were omitted to allow for variations in rainfall early and late in the season.) Calculated as [(Value for Alternative – Value for Best Alternative) divided by (Value for Worst Alternative – Value for Best Alternative)]. The best alternative received a score of 1.0 and the worst received a score of 0.0. This criterion was an attempt to measure the relative effect of dry season flooding on wading bird feeding during the nesting season. Continuous drying, once the dry season commences, is important to wading bird feeding and nesting. Additionally, the region is adjacent to an active nesting population of Cape Sable Seaside Sparrows, who breed in short hydroperiod wetlands during the dry season, provided the ground is not flooded. Since there is some possibility for range expansion into the region if the area is suitable, this index was designed to look at tradeoffs between providing wading bird feeding habitat and sparrow breeding habitat. **This index was calculated, but the results were complicated by the already uncharacteristically dry condition of the region, making it difficult to interpret the results. Raw scores for this index are presented, but were not used to calculate the final score.**
7. Late Wet Season Inundation Index: Proportional measure of how many times during the 31-yr simulation that autumn periods of inundation ended during the months of November and December. **This index was applied only to Indicator Region 5 (Model Lands South), which includes habitat critical for Roseate Spoonbill feeding.** A good year for wading bird feeding would be characterized by standing water in this indicator region well into January. Premature drydowns in the early dry season in this region may severely reduce available food to support Roseate Spoonbill nesting. Calculated as (Value for Alternative – Value for Best Alternative) divided by (Value for Worst Alternative – Value for Best Alternative). The best alternative received a score of 1.0 and the worst received a score of 0.0.

The individual scores were weighted evenly and averaged for each alternative within each indicator region to get comparative scores. Table Model Lands - 1 provides the individual performance index scores, average scores, and ranking of alternatives for each indicator region, followed by an overall evaluation for the Model Lands area. Individual scores for each indicator region are shown separately in Table Model Lands - 1 because of strong differences in results among the regions. Table Model Lands - 2 shows all the scores that were calculated, including some not used in the ranking.

Interpretation

Alternatives A through D

Overall, alternatives that added water to this region yielded higher scores than alternatives that did not. Alternatives B, C, and D consistently scored higher than the base conditions or Alternative A. There were differences among the indicator regions, however, in which alternative produced the best results. Alternative B had the highest score for Indicator Regions 4 and 47 (areas west of US1), while alternatives C and D were essentially indistinguishable for Indicator Regions 5 and 6 (areas east of US1). Alternative B provided additional water to Indicator Region 4 and Indicator Region 47 via the C-111N canal. Alternatives C and D extended the C-111N to Indicator Region 5, which spread the additional water over a larger area and reduced the water remaining in Indicator Region 4 and Indicator Region 47. Alternatives C and D were the configurations resulting in the greatest benefits to the region as a whole and are preferred to Alternative B for that region. A design that benefits the entire region is preferred to one that benefits only a part of it. Furthermore, should an additional source of high quality water be identified in the future, alternatives C or D will provide the infrastructure necessary to distribute this water throughout the Model Lands area. Regional managers are already attempting to reduce artificial hydrological barriers between these indicator regions and manage the entire area as a connected system. Selecting an alternative that benefits the entire area is consistent with their management objectives.

The alternatives that perform the best in this region still are far from meeting targets relative to low water. The objective was to maintain water levels above the stated low water threshold all the time. These targets were based on land elevations and general requirements for historic vegetation communities. Although alternatives C and D, compared with base conditions, improved conditions in the region as a whole, these alternatives still did not reach stated targets. Water levels were below the low water thresholds more than half the time in all four indicator regions.

Alternative D - D13R

The configuration and operation changes from Alternative D to D13R made no difference to hydrologic conditions in the Model Lands-C111 Area. There were no changes in any of the performance indices from D to D13R. According to the performance indices, the water needs of the Model Lands-C111 Area still are not met, although conditions will be improved if either Alternative D or D13R are implemented.

Concerns

Many concerns should be addressed in the detailed design phase. Additional water is needed for the Model Lands-C111 Area. Furthermore, the quality and quantity of some of the water provided to the South Miami-Dade area in Alternative D13R must be confirmed. Some of the benefits in Indicator Region 5 and Indicator Region 6 may have originated from the regional use of advanced treatment wastewater to maintain canal stages in South Miami-Dade, but this option may prove too costly or too impractical to implement.

The benefits of having higher water levels in the Model Lands-C111 Area are clear. Alternative sources of water should, therefore, be identified and investigated as part of the design process.

The specific location and design for the water delivery system need to be carefully considered to minimize impacts to existing high quality wetlands and avoid disrupting the natural system with excessive infrastructure. To maximize benefits, an effort should be made to improve the design to ensure that the best configuration of components has been achieved.

**Model Lands/C-111 Evaluation Matrix, by Indicator Region**

| # | Indicator Region: 4 (C-111 Perrine Marl marsh) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13 |
|---|---|---|---|---|---|---|---|---|---|
| 1a | High Water Events: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0.07 | 0.02 | 0.02 | 0.02 |
| **1** | **High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).** | | **1** | **1** | **1** | **0.93** | **0.98** | **0.98** | **0.98** |
| 2a | Low Water Events: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.855 | 0.83 | 0.83 | 0.43 | 0.55 | 0.55 | 0.55 |
| **2** | **Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).** | | **0.145** | **0.17** | **0.17** | **0.57** | **0.45** | **0.45** | **0.45** |
| 3a | Extreme Low Water Events: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.23 | 0.18 | 0.23 | 0.08 | 0.12 | 0.12 | 0.12 |
| **3** | **Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).** | | **0.77** | **0.82** | **0.77** | **0.92** | **0.88** | **0.88** | **0.88** |
| 4a | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.269 | 0.217 | 0.277 | 0.186 | 0.218 | 0.218 | 0.218 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **4** | **Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)** | | **0.731** | **0.783** | **0.723** | **0.814** | **0.782** | **0.782** | **0.782** |
| 5a | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 8 | 21 | 43 | 58 | 7 | 10 | 9 | 9 |
| **5** | **Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)** | **0.980** | **0.725** | **0.294** | **0.000** | **1.000** | **0.941** | **0.961** | **0.961** |
| 6a | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). **NOT USED in final analysis. | 10 | 16 | 11 | 14 | 13 | 16 | 16 | 16 |
| **6** | **Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-** | **1.000** | **0.000** | **0.833** | **0.333** | **0.500** | **0.000** | **0.000** | **0.000** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) **NOT USED in final analysis.** | | | | | | | | |
| 6b | Dry Season Inundation Pattern: Number of times that water levels rise high enough to provide aquatic habitat (0.2 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). | 8 | 6 | 8 | 8 | 12 | 12 | 12 | 12 |
| 6b | Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise high enough to provide aquatic habitat (0.2 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.667 | 1.000 | 0.667 | 0.667 | 0.000 | 0.000 | 0.000 | 0.000 |

| **#** | **Indicator Region: 5 (Model Lands South) Performance Criteria:** | **NSM** | **95Base** | **2050Base** | **Alt A** | **Alt B** | **Alt C** | **Alt D** | **Alt D13** |
|---|---|---|---|---|---|---|---|---|---|
| 1a | High Water Events: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1** | **High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).** | | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| 2a | Low Water Events: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.87 | 0.94 | 0.94 | 0.855 | 0.665 | 0.665 | 0.665 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **2** | **Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).** | | **0.13** | **0.06** | **0.06** | **0.145** | **0.335** | **0.335** | **0.335** |
| 3a | Extreme Low Water Events: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.25 | 0.21 | 0.23 | 0.11 | 0.06 | 0.06 | 0.06 |
| **3** | **Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).** | | **0.75** | **0.79** | **0.77** | **0.89** | **0.94** | **0.94** | **0.94** |
| 4a | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.287 | 0.223 | 0.245 | 0.129 | 0.090 | 0.090 | 0.090 |
| **4** | **Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)** | | **0.713** | **0.777** | **0.755** | **0.871** | **0.910** | **0.910** | **0.910** |
| 5a | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 18 | 35 | 32 | 33 | 13 | 0 | 0 | 0 |
| **5** | **Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)** | **0.486** | **0.000** | **0.086** | **0.057** | **0.629** | **1.000** | **1.000** | **1.000** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6a | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). **NOT USED in final analysis. | 12 | 13 | 14 | 14 | 14 | 19 | 21 | 21 |
| **6** | **Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) **NOT USED in final analysis.** | **1.000** | **0.889** | **0.778** | **0.778** | **0.778** | **0.222** | **0.000** | **0.000** |
| 7 | Stage Hydrographs: Number of times water levels rise during the period Nov.-Dec. | 10 | 2 | 5 | 6 | 5 | 8 | 7 | 7 |
| 7a | Late Wet Season Water Levels: Number of times any inundation period occurring in the fall ends before January. | 5 | 19 | 14 | 16 | 2 | 1 | 1 | 1 |
| **7** | **Late Wet Season Inundation Index: Comparison among alternatives for number of times any inundation period occurring in the fall ends before January. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)** | **0.778** | **0.000** | **0.278** | **0.167** | **0.944** | **1.000** | **1.000** | **1.000** |

| # | Indicator Region: 6 (Model Lands North) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13 |
|---|---|---|---|---|---|---|---|---|---|
| 1a | High Water Events: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1** | **High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).** | | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| 2a | Low Water Events: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 | 0.93 |
| **2** | **Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).** | | **0.06** | **0.06** | **0.06** | **0.07** | **0.07** | **0.07** | **0.07** |
| 3a | Extreme Low Water Events: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.19 | 0.2 | 0.21 | 0.145 | 0.065 | 0.065 | 0.065 |
| **3** | **Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).** | | **0.81** | **0.8** | **0.79** | **0.855** | **0.935** | **0.935** | **0.935** |
| 4a | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.202 | 0.213 | 0.223 | 0.156 | 0.070 | 0.070 | 0.070 |
| **4** | **Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1** | | **0.798** | **0.787** | **0.777** | **0.844** | **0.930** | **0.930** | **0.930** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **and larger numbers are preferred)** | | | | | | | | |
| 5a | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 9 | 89 | 84 | 82 | 78 | 75 | 73 | 73 |
| **5** | **Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)** | **1.000** | **0.000** | **0.063** | **0.088** | **0.138** | **0.175** | **0.200** | **0.200** |
| 6a | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). **NOT USED in final analysis. | 13 | 6 | 5 | 5 | 10 | 10 | 10 | 10 |
| **6** | **Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) **NOT USED in final analysis.** | **0.000** | **0.875** | **1.000** | **1.000** | **0.375** | **0.375** | **0.375** | **0.375** |

**Indicator Region: 47**

| # | (North C-111) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13 |
|---|---|---|---|---|---|---|---|---|---|
| 1a | High Water Events: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0.03 | 0.05 | 0.05 | 0.05 |
| **1** | **High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).** | | **1** | **1** | **1** | **0.97** | **0.95** | **0.95** | **0.95** |
| 2a | Low Water Events: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.84 | 0.86 | 0.86 | 0.53 | 0.66 | 0.66 | 0.66 |
| **2** | **Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).** | | **0.16** | **0.14** | **0.14** | **0.47** | **0.34** | **0.34** | **0.34** |
| 3a | Extreme Low Water Events: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.155 | 0.15 | 0.25 | 0.07 | 0.065 | 0.065 | 0.065 |
| **3** | **Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).** | | **0.845** | **0.85** | **0.75** | **0.93** | **0.935** | **0.935** | **0.935** |
| 4a | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.185 | 0.174 | 0.291 | 0.132 | 0.098 | 0.098 | 0.098 |
| **4** | **Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)** | | **0.815** | **0.826** | **0.709** | **0.868** | **0.902** | **0.902** | **0.902** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5a | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 19 | 61 | 62 | 59 | 35 | 41 | 38 | 38 |
| **5** | **Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)** | **1.000** | **0.023** | **0.000** | **0.070** | **0.628** | **0.488** | **0.558** | **0.558** |
| 6a | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). **NOT USED in final analysis. | 10 | 3 | 3 | 3 | 5 | 4 | 5 | 5 |
| **6** | **Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) **NOT USED in final analysis.** | **0.000** | **1.000** | **1.000** | **1.000** | **0.714** | **0.857** | **0.714** | **0.714** |

**Table Model Lands - 1 Model Lands/C-111 Summary Matrix, by Indicator Region**

| # | Indicator Region: 4 (C-111 Perrine Marl Marsh) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13R |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Stage Duration Curve: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0.07 | 0.02 | 0.02 | 0.02 |
| 1 | High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1). | | 1 | 1 | 1 | 0.93 | 0.98 | 0.98 | 0.98 |
| 2 | Stage Duration Curve: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.855 | 0.83 | 0.83 | 0.43 | 0.55 | 0.55 | 0.55 |
| 2 | Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1). | | 0.145 | 0.17 | 0.17 | 0.57 | 0.45 | 0.45 | 0.45 |
| 3 | Stage Duration Curve: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.23 | 0.18 | 0.23 | 0.08 | 0.12 | 0.12 | 0.12 |
| 3 | Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1). | | 0.77 | 0.82 | 0.77 | 0.92 | 0.88 | 0.88 | 0.88 |
| 4 | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.269 | 0.217 | 0.277 | 0.186 | 0.218 | 0.218 | 0.218 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred) | | 0.731 | 0.783 | 0.723 | 0.814 | 0.782 | 0.782 | 0.782 |
| 5a | Wet Season Inundation Pattern: Number of times water levels drop below surface elevation (= 0 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 8 | 21 | 22 | 26 | 4 | 6 | 6 | 6 |
| 5a | Wet Season Inundation Pattern Index: Comparison among alternatives for number of times water levels drop below surface elevation (= 0 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.818 | 0.227 | 0.182 | 0.000 | 1.000 | 0.909 | 0.909 | 0.909 |
| 5b | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 8 | 21 | 43 | 58 | 7 | 10 | 9 | 9 |
| 5 | Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst | 0.980 | 0.725 | 0.294 | 0.000 | 1.000 | 0.941 | 0.961 | 0.961 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Alternative). (Range 0 - 1, 1 Best.) | | | | | | | | |
| 6a | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). | 10 | 16 | 11 | 14 | 13 | 16 | 16 | 16 |
| 6 | Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 1.000 | 0.000 | 0.833 | 0.333 | 0.500 | 0.000 | 0.000 | 0.000 |
| 6b | Dry Season Inundation Pattern: Number of times that water levels rise high enough to provide aquatic habitat (0.2 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). | 8 | 6 | 8 | 8 | 12 | 12 | 12 | 12 |
| 6b | Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise high enough to provide aquatic habitat (0.2 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.667 | 1.000 | 0.667 | 0.667 | 0.000 | 0.000 | 0.000 | 0.000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| [redacted] | Total Average Score using 5a, 6a (0 ft on reversals): | 0.479 | 0.631 | 0.499 | 0.789 | 0.667 | 0.667 | 0.667 |
| | Rank on Avg in R20 | 5 | 3 | 4 | 1 | 2 | 2 | 2 |
| | Total Average Score using 5b, 6b(.2 ft on reversals): | 0.729 | 0.622 | 0.555 | 0.706 | 0.672 | 0.675 | 0.675 |
| | Rank on Avg in R22 | 1 | 5 | 6 | 2 | 4 | 3 | 3 |
| | Total Average Score: | 0.674 | 0.613 | 0.533 | 0.847 | 0.807 | 0.811 | 0.811 |
| | Rank on Total Avg Score (1 = Best of Group) | 3 | 4 | 5 | 1 | 2 | 2 | 2 |

| # | Indicator Region: 5 (Model Lands South) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13R |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Stage Duration Curve: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1). | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | Stage Duration Curve: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.87 | 0.94 | 0.94 | 0.855 | 0.665 | 0.665 | 0.665 |
| 2 | Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1). | | 0.13 | 0.06 | 0.06 | 0.145 | 0.335 | 0.335 | 0.335 |
| 3 | Stage Duration Curve: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.25 | 0.21 | 0.23 | 0.11 | 0.06 | 0.06 | 0.06 |
| 3 | Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1). | | 0.75 | 0.79 | 0.77 | 0.89 | 0.94 | 0.94 | 0.94 |
| 4 | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.287 | 0.223 | 0.245 | 0.129 | 0.090 | 0.090 | 0.090 |
| 4 | Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 | | 0.713 | 0.777 | 0.755 | 0.871 | 0.910 | 0.910 | 0.910 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | and larger numbers are preferred) | | | | | | | | |
| 5 | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 18 | 35 | 32 | 33 | 13 | 0 | 0 | 0 |
| 5 | Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.486 | 0.000 | 0.086 | 0.057 | 0.629 | 1.000 | 1.000 | 1.000 |
| 6 | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). | 12 | 13 | 14 | 14 | 14 | 19 | 21 | 21 |
| 6 | Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 1.000 | 0.889 | 0.778 | 0.778 | 0.778 | 0.222 | 0.000 | 0.000 |
| 7 | Stage Hydrographs: Number of times water | 10 | 2 | 5 | 6 | 5 | 8 | 7 | 7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | levels rise during the period Nov.-Dec. | | | | | | | | |
| 7 | Late Season Water Levels: Number of times any inundation period occurring in the fall ends before January. | 5 | 19 | 14 | 16 | 2 | 1 | 1 | 1 |
| 7 | Late Wet Season Inundation Index: Comparison among alternatives for number of times any inundation period occurring in the fall ends before January. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.778 | 0.000 | 0.278 | 0.167 | 0.944 | 1.000 | 1.000 | 1.000 |
| | Total Average Score: | | 0.432 | 0.498 | 0.468 | 0.747 | 0.864 | 0.864 | 0.864 |
| | Rank on Total Avg Score (1 = Best of Group) | | 5 | 3 | 4 | 2 | 1 | 1 | 1 |

| # | Indicator Region: 6 (Model Lands North) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13R |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Stage Duration Curve: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1). | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | Stage Duration Curve: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 | 0.93 |
| 2 | Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1). | | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| 3 | Stage Duration Curve: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.19 | 0.2 | 0.21 | 0.145 | 0.065 | 0.065 | 0.065 |
| 3 | Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1). | | 0.81 | 0.8 | 0.79 | 0.855 | 0.935 | 0.935 | 0.935 |
| 4 | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.202 | 0.213 | 0.223 | 0.156 | 0.070 | 0.070 | 0.070 |
| 4 | Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 | | 0.798 | 0.787 | 0.777 | 0.844 | 0.930 | 0.930 | 0.930 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | and larger numbers are preferred) | | | | | | | |
| 5 | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 9 | 89 | 84 | 82 | 78 | 75 | 73 | 73 |
| 5 | Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 1.000 | 0.000 | 0.063 | 0.088 | 0.138 | 0.175 | 0.200 | 0.200 |
| 6 | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). | 13 | 6 | 5 | 5 | 10 | 10 | 10 | 10 |
| 6 | Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative- Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.000 | 0.875 | 1.000 | 1.000 | 0.375 | 0.375 | 0.375 | 0.375 |
| | Total Average Score: | | 0.534 | 0.542 | 0.543 | 0.581 | 0.622 | 0.627 | 0.627 |
| | Rank on Total Avg Score (1 | | 4 | 3 | 3 | 2 | 1 | 1 | 1 |

= Best of Group)

| # | Indicator Region: 47 (North C-111) Performance Criteria: | NSM | 95Base | 2050Base | Alt A | Alt B | Alt C | Alt D | Alt D13R |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Stage Duration Curve: Percentage of time water levels are above the specified high-water depth (Target = 0; <10% acceptable). | | 0 | 0 | 0 | 0.03 | 0.05 | 0.05 | 0.05 |
| 1 | High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1). | | 1 | 1 | 1 | 0.97 | 0.95 | 0.95 | 0.95 |
| 2 | Stage Duration Curve: Percentage of time water levels are below the specified low water level (Target = 0). | | 0.84 | 0.86 | 0.86 | 0.53 | 0.66 | 0.66 | 0.66 |
| 2 | Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1). | | 0.16 | 0.14 | 0.14 | 0.47 | 0.34 | 0.34 | 0.34 |
| 3 | Stage Duration Curve: Percentage of time water levels fall more than 1 ft below specified low-water target (Target = 0). | | 0.155 | 0.15 | 0.25 | 0.07 | 0.065 | 0.065 | 0.065 |
| 3 | Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1). | | 0.845 | 0.85 | 0.75 | 0.93 | 0.935 | 0.935 | 0.935 |
| 4 | Relative dry period slope index (Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 0 and smaller numbers are preferred) | | 0.185 | 0.174 | 0.291 | 0.132 | 0.098 | 0.098 | 0.098 |
| 4 | Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 | | 0.815 | 0.826 | 0.709 | 0.868 | 0.902 | 0.902 | 0.902 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | and larger numbers are preferred) | | | | | | | | |
| 5 | Wet Season Inundation Pattern: Number of times water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. (Target = fewer events than NSM). | 19 | 61 | 62 | 59 | 35 | 41 | 38 | 38 |
| 5 | Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 1.000 | 0.023 | 0.000 | 0.070 | 0.628 | 0.488 | 0.558 | 0.558 |
| 6 | Dry Season Inundation Pattern: Number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May (Target = fewer events than NSM). | 10 | 3 | 3 | 3 | 5 | 4 | 5 | 5 |
| 6 | Dry Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels rise above surface elevation (0 ft on graph) during dry season period Jan-May. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.) | 0.000 | 1.000 | 1.000 | 1.000 | 0.714 | 0.857 | 0.714 | 0.714 |
| | Total Average Score: | | 0.569 | 0.563 | 0.534 | 0.773 | 0.723 | 0.737 | 0.737 |
| | Rank on Total Avg Score (1 | | 4 | 4 | 5 | 1 | 3 | 2 | 2 |

= Best of Group)

**Table Model Lands - 2**

| **Indicator Region Average Score** | **NSM** | **95Base** | **2050Base** | **Alt A** | **Alt B** | **Alt C** | **Alt D** | **Alt D13R** |
|---|---|---|---|---|---|---|---|---|
| Indicator Region 4 (C-111 Perrine Marl Marsh) | | 0.674 | 0.613 | 0.533 | 0.847 | 0.807 | 0.811 | 0.811 |
| Indicator Region 5 (Model Lands South) | | 0.432 | 0.498 | 0.468 | 0.747 | 0.864 | 0.864 | 0.864 |
| Indicator Region 6 (Model Lands North) | | 0.534 | 0.542 | 0.543 | 0.581 | 0.622 | 0.627 | 0.627 |
| Indicator Region 47 (North C-111) | | 0.569 | 0.563 | 0.534 | 0.773 | 0.723 | 0.737 | 0.737 |
| Total Regional Average Score | | 0.552 | 0.554 | 0.519 | 0.737 | 0.754 | 0.760 | 0.760 |
| Regional Average Score Ranking | | 5 | 5 | 4 | 3 | 2 | 1 | 1 |

## G. Big Cypress Subregion

### Area/Subregion/Indicator Regions

Different portions of the Big Cypress subregion are used in the different matrix equations.

### Performance Measures

1. Mean NSM Hydroperiod Matches for North Big Cypress National Preserve for the 31 year simulation
2. Mean NSM Hydroperiod Matches for South Big Cypress National Preserve for the 31 year simulation
3. Normalized Weekly Stage Duration Curves for Indicator Regions 13, 31, 36-40, 45, and 42-43
4. Average Annual Overland Flows toward Gulf of Mexico from Big Cypress National Preserve for the 31 year simulation
5. Inundation Duration Summary for Indicator Regions: Average Flood Duration

### Scoring Explanation

All of the scores are relative to NSM conditions in the Big Cypress.

**A = percent of North Big Cypress National Preserve that matches NSM (PM #1)**

This provides a spatial measure of one of the more impacted portions of the Big Cypress that lies along its northern border. Impacts are due primarily to agricultural development and its associated canals upstream (north) of this area. In addition, there may be some model boundary problems in this area, possibly related to the fact that the area to the north is included in the Natural System Model, but not the South Florida Water Management Model.

**B = percent of South Big Cypress National Preserve that matches NSM (PM #2)**

This provides a spatial measure of the relatively unimpacted portion of the Big Cypress. This area is dominated by rainfall inputs, and as a result, exhibits few effects of hydrologic alterations beyond its boundaries. Hydrologic effects of the Restudy alternatives occur primarily along the Big Cypress boundary with the Everglades.

**C (for individual Indicator Regions) = 1 - {absolute number}**

[(percent of time flooded for NSM) - (percent of time flooded for Base or Alternative)] /100} (PM #3)

This provides a measure of deviation from NSM hydroperiod for an indicator region. This deviation is almost always a reduction in hydroperiod. The selected indicator regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the alternatives on the western portion of the Big Cypress. Initially all of the indicator regions were evaluated separately (Table Big Cypress - 1).

Equations were developed to combine some indicator regions in a simple additive form because of different influences in different areas (Table Big Cypress - 2). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

**$D_n$(for individual Indicator Regions) = 1 – absolute number**
[(maximum deviation from NSM hydrograph) / (maximum range of NSM water level fluctuation)] (PM #3)

This provides a measure how much water levels have been altered from NSM conditions as a function of the NSM range of fluctuation for an indicator region. A certain degree of deviation in an area with a large natural fluctuation would be less significant than in an area with a small natural fluctuation. Typically, the greatest deviation occurs when the water table is declining through the first foot or two below the ground surface, it is smallest at its lowest point on the hydrograph, and it is relatively small when the water table is above ground. The selected indicator regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the alternatives on the western portion of the Big Cypress. Initially all of the indicator regions were evaluated separately (Table Big Cypress - 1).

Equations were developed to combine some indicator regions in a simple additive form because of different influences in different areas (Table Big Cypress - 2). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

**G = 1 – absolute number [(deviation of average flood**
duration from NSM average flood duration) / (NSM average flood duration)] (PM #5)

This provides a measure of deviation from NSM for average duration of individual flooding events for an indicator region. This deviation is usually a reduction in the duration of inundation. The selected Indicator Regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the alternatives on the western portion of the Big Cypress. Initially all of the indicator regions were evaluated separately (Table Big Cypress - 1).

Equations were developed to combine some indicator regions in a simple additive form because of different influences in different areas (Table Big Cypress - 2). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big

Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

**$E_w$ = 1 – absolute number [(deviation of wet season flows**
from NSM flows) / (NSM wet season flows)] (PM #4)

**$E_d$ = 1 – absolute number [(deviation of dry season flows**
from NSM flows) / (NSM dry season flows)] (PM #4)

Total flows during the wet and dry season provide another way of expressing hydrologic conditions and how they change in response to proposed alternatives in particular portions of the Big Cypress. The flow cross-sections evaluated included the Eastern Big Cypress and Lostman's. Initially the flow cross-sections were evaluated separately by wet and dry season (Table Big Cypress - 1).

The subteam has developed simple additive equations for each flow cross-section to combine the wet and dry season information (Table Big Cypress - 2).

**Summary Equations**

The subteam subsequently developed summary equations for major geographic regions of the Big Cypress that were distinct in terms of their response to the various Restudy alternatives (Table Big Cypress - 2). These major areas were: **North Big Cypress**, which was only affected by Alternatives C and D where the L-28 Interceptor canal and levee system were modified; **South Big Cypress**, which was affected primarily by alterations to the south end of the L-28 canal and levee and in the adjacent Water Conservation Area 3A; and **Southeast Big Cypress**, which being on the border between the Everglades and southeast portion of the Big Cypress Swamp, is affected by the numerous alterations to the Everglades.

For each of these geographic areas, a simple additive equation was developed to combine variables $C_n$, $D_n$ and $G_n$ for the same indicator region(s) to summarize information on deviations in hydroperiod, water depth, and average flood event duration in these areas. In North Big Cypress, variable A was included in this simple additive equation. In South Big Cypress, variable B and variable E were included for flows across the Eastern Big Cypress along Tamiami Trail. In Southeast Big Cypress, variable E was included for flows across the Lostman's cross-section south of Tamiami Trail.

A single equation was also developed that combined the three Big Cypress regions.

**Discussion**

Scores were developed separately for each variable in each indicator region and for each cross-section or boundary (Table Big Cypress - 1). They were then combined in a stepwise fashion, as described above, so that the AET would be able to comment on what is gained and lost as each performance measure was combined with others. Originally two sets were developed (with or without flows) of the three summarizing equations, with the goal of reducing all of the variables to three scores, one for the North Big Cypress, one for the South Big Cypress, and one for the southeastern Big Cypress. Ultimately two whole Big Cypress equations were produced, again depending on whether flow parameters are used or not in the equations.

As a result of discussions at the late May AET meetings, it was decided to focus on using the information contained in the three geographically-separate equations that included the flow cross-section information (Table Big Cypress - 2). Each of these three summary rows of the matrix provided distinctive information relevant to understanding influences that each of the Alternatives had on the Big Cypress.

All of the effects on the North Big Cypress occurred in Alternatives C and D, and were retained in D13 and D13R. The effects resulted from filling the L-28 Interceptor Canal and removing its western levee, creating openings for water to move south along the Western Feeder Canal, and replacing S-190 with a pump station to maintain upstream drainage. This scenario also required some sort of water treatment capability to assure that all water moving south and southwest from the upstream canal system would provide only clean water. These components converted an area about two cells wide for most of the length of the L-28 Interceptor along its western side to approximately NSM conditions. Because the locations of the restored cells and the indicator regions available in the vicinity were not the same, the low matrix scores did not adequately reflect the high degree of restoration that actually occurred in portions of this area from the implementation of these components.

In the South Big Cypress, the most significant changes occurred in Alternative D, with the removal of the L-28 Tieback Levee. With this structure removed, hydrologic conditions showed almost complete restoration to NSM conditions, including restored hydroperiods and increased flows across the eastern portion of the Big Cypress. The model results for D13 and D13R were almost identical to one another, and both showed generally small but distinct increased deviations from NSM as compared to Alternative D. The matrix values for D13 were almost identical to the 1995 Base conditions in this area, but were higher than for the 2050 Base. When looking at the hydrologic responses to these alternatives for individual performance measures and indicator regions, the geographic area where the deviations were greatest was in the vicinity and downstream of the jetport. It has not been evaluated how the jetport is modeled in the SFWMM, and it is possible that the fill associated with it may be extensive enough to be cutting off flows through this area under the hydrologic conditions that exist in Alternative D13.

In the southeastern Big Cypress along its border with the Everglades and below Tamiami Trail, the most significant changes occurred in Alternative B, when the L-28 and L-29 levees and canals were removed. According to the model, there were larger areas showing reduced hydroperiods and the reductions in hydroperiods and flows were greater than in Alternatives A, C, or D, all of which were close to NSM condition. In Alternative C, the L-28 and only the western portion of L-29 were restored, which was sufficient to return conditions in this area close to NSM. The removal of the L-28 Tieback in Alternative D did not seem to affect this portion of the Big Cypress. Alternatives D13 and D13R produced generally small and variable responses among the various performance measures, resulting in an overall minor difference in the summary matrix value for this portion of the Big Cypress.

**Summary**

The combination of components in Alternative D produced the greatest benefits in terms of restoring the largest amount of area in the Big Cypress to approximately NSM conditions. It also seems that several of the most beneficial components could be implemented in any of the alternatives, since they operate pretty much independently from the rest of the Everglades ecosystem. This would be the situation for the L-28 Interceptor and L-28 Tieback components. Changes to the L-28 South and L-29 have more extensive and complex interactions with other parts of the Everglades.

In using the colors and grades to differentiate restoration success as indicated by the various performance measures for each the bases and alternatives (A-D, D13, D13R), matrix value ranges of 91-100 (green, grade A), 81-90 (yellow, grade B), and <81 (red, grade C) were used. These ranges generally seemed to do a reasonably good job of sorting restoration gains and losses for the Big Cypress region that were associated with each of the alternatives. The only portion of the region where these results could be misinterpreted is the North Big Cypress. The portion of this area influenced by the L-28 Interceptor system should be included in the green grade A category in Alternatives C, D, D13, and D13R. The portion further west still shows severe hydrologic impacts, even in these latter alternatives. However, based on a helicopter overflight of the area to assess its condition and understanding of how the models are operating in this area, it is very likely that these impacts are merely the result of modeling problems, and in reality are much less severe than suggested by the SFWMM.

Information on the hydrologic influences of L-28 South provided by the Restudy modeling efforts and by an Army Corps of Engineers consultant indicated that the presence of the L-28 helps to maintain NSM conditions in the area. The subteam has been told that other information developed by the National Park Service does not support this conclusion. However, the subteam has not seen this information, and are unable to comment on how it would influence current conclusions.

**NORTH BIG CYPRESS**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Percent of North Big Cypress that Matches NSM / 100 | | | | | | |
| A | 1.00 | 0.47 | 0.46 | 0.46 | 0.49 | 0.64 | 0.64 | 0.64 |
| | | Reduction in Percent of Time Inundated from NSM Condition | | | | | | |
| C42-C43 | 1.00 | 0.58 | 0.58 | 0.58 | 0.58 | 0.78 | 0.78 | 0.78 |
| | | Maximum Deviation from NSM Stage Duration Curve | | | | | | |
| D42-D43 | 1.00 | 0.70 | 0.70 | 0.70 | 0.70 | 0.76 | 0.76 | 0.76 |
| | | Average Flood Duration | | | | | | |
| G42-G43 | 1.00 | 0.34 | 0.34 | 0.34 | 0.34 | 0.59 | 0.59 | 0.59 |
| | | Summary - North Big Cypress | | | | | | |
| | 1.00 | 0.52 | 0.52 | 0.52 | 0.53 | 0.69 | 0.69 | 0.69 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SOUTH BIG CYPRESS** | | | | | | | | |
| | | Percent of South Big Cypress that Matches NSM / 100 | | | | | | |
| B | 1.00 | 0.99 | 0.97 | 0.97 | 0.92 | 0.99 | 1.00 | 1.00 |
| | | Reduction in Percent of Time Inundated from NSM Condition | | | | | | |
| C31, C36-C40 | 1.00 | 0.95 | 0.94 | 0.94 | 0.94 | 0.96 | 0.98 | 0.96 |
| | | Maximum Deviation from NSM Stage Duration Curve | | | | | | |
| D31, D36-D40 | 1.00 | 0.97 | 0.96 | 0.96 | 0.96 | 0.97 | 0.98 | 0.97 |
| | | Average Flood Duration | | | | | | |
| G31, G36-G40 | 1.00 | 0.89 | 0.85 | 0.84 | 0.85 | 0.87 | 0.95 | 0.90 |
| | | Percent Change in Flow from NSM Condition / 100 | | | | | | |
| (Ew+Ed)/2 East BC | 1.00 | 0.70 | 0.63 | 0.58 | 0.62 | 0.66 | 0.88 | 0.74 |
| | | Summary - South Big Cypress | | | | | | |
| | 1.00 | 0.90 | 0.87 | 0.86 | 0.86 | 0.89 | 0.96 | 0.92 |
| **SOUTHEAST BIG CYPRESS** | | | | | | | | |
| | | Reduction in Percent of Time Inundated from NSM Condition | | | | | | |
| C-13 | 1.00 | 0.99 | 0.93 | 0.99 | 0.95 | 0.99 | 0.99 | 0.99 |
| | | Maximum Deviation from NSM Stage Duration Curve | | | | | | |
| D-13 | 1.00 | 0.95 | 0.92 | 0.98 | 0.95 | 0.96 | 0.97 | 0.99 |
| | | Average Flood Duration | | | | | | |
| G-13 | 1.00 | 0.93 | 0.89 | 0.96 | 0.86 | 1.00 | 1.00 | 0.86 |
| | | Percent Change in Flow from NSM Condition / 100 | | | | | | |
| (Ew+Ed)/2 Lostman's | 1.00 | 0.61 | 0.55 | 0.92 | 0.71 | 0.94 | 0.92 | 0.98 |
| | | Summary - Southeast Big Cypress | | | | | | |
| | 1.00 | 0.87 | 0.82 | 0.96 | 0.87 | 0.97 | 0.97 | 0.95 |

### H. Estuaries and Bays

The geographical regions covered by these performance measures are:
1. The Caloosahatchee Estuary;
2. The St. Lucie Estuary; and
3. The Lake Worth Lagoon

The following is a list of the performance measures for the estuaries in this subregion:

**Caloosahatchee Estuary**
1. Performance Measure: The number of times salinity envelope criteria were not met for the Caloosahatchee Estuary.
2. Performance Measure: The number of times high discharge criteria (mean monthly flow > 2,800 and 4,500 cfs) were exceeded for the Caloosahatchee Estuary.
3. Performance Measure: Regulatory releases from Lake Okeechobee.

**St. Lucie Estuary**
1. Performance Measure: Number of times salinity envelope criteria were not met for the St. Lucie Estuary.
2. Performance Measure: Number of times high discharge criteria (mean monthly flow > 1,600 & 2,500 cfs) were exceeded for the St. Lucie Estuary.
3. Performance Measure: Minimum flow to the St. Lucie Estuary (350 cfs).

**Lake Worth Lagoon**
1. Performance Measure: Wet/Dry Season Average Flows Discharged to Lake Worth through S-40, S-41 & S-155 for the 31-year simulation.

**Variables and Performance Measures for the Caloosahatchee Estuary**

The following variables were developed using existing performance measures for Caloosahatchee Estuary. The variables / performance measures have targets based on flow which would support optimum hydrologic conditions conducive of optimum quality habitat for fish, wildlife, and other aquatic resources. The targets are based on optimization model outputs, natural variation that would occur during the period 1965-1995, and desirable salinity conditions for existing and potential aquatic resources within the Caloosahatchee Estuary. These are not all of the existing performance measures for the Caloosahatchee Estuary but are a subset selected by the subteam to be used to evaluate Restudy Plans. There are additional performance measures posted on the Restudy webpage that provide additional detailed information. These additional performance measures were determined to be a lower level priority to be used in the present Restudy evaluation and may not be included in Restudy AET presentations/evaluations.

**Variables, SIVs**. The four variables / performance measures for the Caloosahatchee Estuary are as follows:

SI**V*min*** = # months mean monthly flow< 300 cfs from C-43 & LOK during dry season (Nov – May)

**SIV*max2800*** = # months mean monthly flow > 2,800 cfs

**SIV*max4500*** = # months mean monthly flows were > 4,500 cfs

**SIV*max800*** = # days LOK Reg. Discharges>7800 cfs.

**SIV*min*.** This variable is based on the number of months with mean monthly flow< 300 cfs. This variable is based on the number of times the minimum mean monthly flows from the lake and watershed fall below 300 cfs at S-79 for the 1965-1995 period. The alternative with the least number of times flows fall below 300 cfs, as measured at S-79, will be considered better for protecting estuarine aquatic biota. The target number of months not to be exceeded is 60 for the 1965-1995 period.

**Principal Objective**: Maintain sufficient minimum mean monthly flows from the lake to augment basin runoff, when necessary, in order to maintain favorable salinities and water quality within the estuary.

**Rationale**: Insufficient fresh water discharges, contribute to poor estuarine water quality including inadequate fresh water to maintain desirable salinity envelopes. These events have had direct effects on estuarine seagrasses, fish and invertebrates, including critical indicator species eg. Vallisneria, by enabling the estuary to become too saline

**Outputs for SIV*min***: As stated above, the ROGEM indices are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling indicate that the optimum senario would have no more than 60 months of mean monthly flows of <300 cfs. The Caloosahatchee data for the alternatives is taken from the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target )}}$$

Note: The output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*min* are presented in Table Caloosahatchee Estuary - 1.

**SIV*max2800***. This variable is based on the number of times mean monthly flow exceeds 2,800 cfs as measured at S-79 from the lake and the watershed for the 1965-1995 period. The maximum number of months (target) allowing for natural variation is 22 for the 1965-1995 period of record. The alternative with the least number of times flows exceed 2,800 cfs as measured at S-79, at any time of year, will be considered better for maintaining desirable salinity and water quality within the estuary.

**Principal Objective**: Achieve an overall reduction in high volume discharge events to the estuary, and improve estuarine water quality. This will benefit estuarine vegetation, invertebrates, and fish communities.

**Rationale**: High volume discharges to the estuary contribute to poor estuarine water quality including increased turbidity, color and violation of favorable salinity envelopes. High flow events have direct effects on estuarine seagrasses by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat, and contributing to unfavorable salinities for aquatic vegetation, fish and invertebrates, including critical indicator species e.g., the American oyster, turtle grass, and Vallisneria.

**Outputs for SIV*max2800:*** As stated above, the ROGEM scores are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling of this period indicate that the optimum scenario would have no more than 22 months of mean monthly flows of >2800 cfs. The Caloosahatchee Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target )}}$$

Note: The maximum output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*max2800* are presented in Table Caloosahatchee Estuary - 1.

**SIV*max4500***. This variable is based on the number of times mean monthly flows exceed 4,500 cfs at S-79 for the 1965-1995 period of record. The acceptable number of months (target) allowing for natural variation is 6 for the 1965-1995 period. The alternative with the least number of months that discharges exceed 4,500 cfs as measured at S-79, will be considered better for protecting estuarine resources, including those downstream in the San Carlos Bay region.

**Principal Objective**: Reduce the occurrence of extreme discharge events and improve water quality in the lower estuary, including San Carlos Bay, in order to protect estuarine resources.

**Rationale**: Mean monthly flows above 4,500 cfs results in freshwater conditions throughout the entire estuary causing impacts to estuarine biota. This volume of flow also begins to reduce water quality and adversely impact biota in San Carlos Bay.

**Outputs for SIV*max4500:*** The ROGEM scores are ordinal numbers. The total allowable number of monthly violations, based on natural variation of hydrologic conditions, and hydrologic modeling of this period indicate that the optimum condition is to have no more than 6 months of mean monthly flows of >4500 cfs. The Caloosahatchee Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target )}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions

Results for SIV*max4500* are presented in Table Caloosahatchee Estuary - 1.

**SIV*max7800*.** This variable is based on the number of days of Zone A discharge from the lake for each alternative for the period 1965-1995. The target is zero (0) violations. This variable considers the number of days of Zone A discharge from the lake (7,800 cfs per day at S-79, not S-77) for each alternative for the 1965-1995 period of record. The alternatives with the least number of days of Zone A release according to output from the SFWMM will be considered better for protecting the integrity of the estuarine environment.

**Principal Objective**: Reduce the occurrence of extreme discharge events from the lake to the estuary, and improve estuarine water quality with a view to protecting estuarine aquatic biota.

**Rationale**: Zone A discharges have rapid and serious effects on estuarine seagrasses in the Caloosahatchee River Estuary and San Carlos Bay by reducing light penetration necessary for photosynthesis. Zone A discharges destroy fish and invertebrate habitat, and contribute to unfavorable salinities for estuarine biota, including critical indicator species e.g., the American oyster, Vallisneria, and other vegetation. The longer Zone A discharges persist, the greater the damage to the various ecosystems, and the further the damage extends.

**Outputs for SIV*max7800***: No Zone A discharges of this magnitude are desirable. Furthermore, the results of hydrologic modeling of the period 1965-1995 indicate that no daily flows of >7800 cfs would have occurred during this period. The Caloosahatchee Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahachee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of days}}{\text{range (observed max \# days for all alts )}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates maximum conditions.

Results for SIV*max7800* are presented in Table Caloosahatchee Estuary - 1.

**ROGEM equation and final scores for Caloosahatchee Estuary**

The variables can be prioritized from lowest to highest, according to the following: SIVmin is the lowest priority variable, followed by SIVmax 2800, which is lower than SIVmax 4500, which is followed by SIVmax7800 (Zone A regulatory releases >7,800 cfs from Lake Okeechobee, the highest priority variable for the Caloosahatchee). Note, however, that all these variables / performance measures are considered first order priority variables even though it is possible to rate them relatively among each other. All variables are weighted equally in the ROGEM equation.

ROGEM scores for Caloosahatchee are calculated according to the following:

1/4 (SIV*min* + SIV*max2800* + SIV*max4500* + SIV*max7800)*

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Scores for all of the plans and the two base cases are presented in Table Caloosahatchee Estuary - 1. To summarize: Alternatives A through D13R all scored 1.0 on a scale of 0.0 to 1.0. The Caloosahatchee subteam agrees that any of the alternatives would be considered very good for Caloosahatchee Estuary. All the alternatives greatly exceed the target values set in the performance measures (except for regulatory releases, which meets the target). Furthermore, alternatives A through D show major improvements over the 1995 Base, which scored 0.0, and the 2050 Base, which scored 0.1. Because all but one of the regulatory releases were eliminated in plans A through D13R, SIV*max7800* was not weighted more heavily than the other variables. However, if the plans had not been so successful in eliminating the Zone A regulatory discharges then SIV*max7800* would have been weighted.

**Variables and Performance Measures for the St. Lucie Estuary**

The suitability index variables (SIVs) were developed using existing performance measures for St. Lucie Estuary. The variables / performance measures have targets based on flow that would support optimum hydrologic conditions conducive of optimum quality habitat for fish, wildlife, and other aquatic resources. The targets are based on optimization model outputs, natural variation that would occur during the period 1965-1995, and desirable salinity conditions for existing and potential aquatic resources within the St. Lucie Estuary. These are not all of the existing performance measure for the St. Lucie Estuary but are a subset selected by the St. Lucie subteam to be used to evaluate Restudy plans. There are additional performance measures posted on the Restudy web page that also provide information for the estuary. However, the additional performance measures were determined to be a lower level priority for the present Restudy evaluation and are not included in the present presentations / evaluations.

The St. Lucie Estuary River of Grass Evaluation Methodology (ROGEM) is comprised of four metrics (suitability index variables, or SIVs) that concern maintenance of desirable salinity conditions within the St. Lucie Estuary. The SIVs are based on research, empirical findings, and a hydrologic analysis of the period 1965 through 1995. The ROGEM outputs are ordinal numbers. Ordinal scores are calculated based on performance measure (PM) targets for each of the variables. The highest possible score of 1.0 represents optimum hydrologic conditions conducive of optimum quality habitat for the estuarine indicator species chosen (oysters and sumberged aquatic vegetation (SAV)). Decreasing scores to 0.0 represent decreasing habitat quality.

The St. Lucie Estuary receives freshwater inputs both through interbasin transfer from Lake Okeechobee and from local watershed contributions. The maintenance of flows to the estuary to achieve the appropriate salinity regime therefore must manage both watershed runoff and regulatory flows from the lake. Several performance measures from the SFWMM dealing with various inflows to the estuary were selected for ROGEM to compare alternative restoration scenarios. On the most basic level, inflow problems can be divided into two categories: 1) High inflow events, when large regulatory releases from the Lake and / or the watershed cause poor estuarine water quality and 2) Maintaining dry season base flows. Minimum levels of inflow and nutrients usually occur at the end of the dry season (April and May). It is during these months that numerous species of juvenile fish depend on an abundant food supply of phytoplankton and zooplankton, which requires a minimum level of fresh water and nutrients. In order for the estuary to act as a nursery for juvenile fish, plankton populations should be at a high enough density for fish to easily feed.

To determine appropriate water quantity inflows to the estuary, biological indicators with definable salinity preferences were chosen. A favorable range of salinities for the estuary were determined (referred to as the salinity envelope) based on the requirements of SAV and oysters. Woodward-Clyde, in a literature review report developed for the District in 1998, summarizes the approximate salinity tolerances for selected SAV and American oyster. A report on the abundance and type of SAV species by Phillips and Ingle (1960), provided the most complete source of information on SAV occurrence and abundance in the St. Lucie Estuary. This survey of SAV which was conducted from September 1957 to March 1959 revealed that the three most commonly found species of SAV in the estuary at the time were shoal grass (outer and middle estuary), manatee grass (outer estuary), and widgeon grass (north fork). They also reported on the salinity tolerance, normal, common and optimum range for all species. The normal tolerance range for shoal grass is 5-55 ppt; for manatee grass, 17-44 ppt; and for widgeon grass, 0-45 ppt. These numbers were based on reviewed literature, and all species can withstand even greater salinity fluctuations for short periods of time. The salinity tolerance ranges were also summarized for the different life cycle stages of the American oyster. The optimum range for adults and juveniles is 10-20 ppt, 20-23 for spat, 23-27 for larvae and embryos and 15-20 ppt for a sustainable population (Woodward-Clyde 1998). More details can be found in tables 13-3 and 13-4 of the report. These favorable ranges of salinity (salinity envelope) have been related to volumes of freshwater flow to the estuary and a target range of flows was determined. In order to meet the salinity envelope criteria the surface water flows coming from the watershed as well as from ground water should be in the range of 350cfs - 1600cfs. The ROGEM model for the estuary is based on four sets of variables (or performance measures). Each variable has an acceptable number of violations of the upper and lower flow range to take into consideration natural variation of flow.

**Variables, SIVs**. The ROGEM equation for St. Lucie Estuary includes the following four variables:

**SIV*min*** = # of months with mean monthly flow < 350 cfs
**SIV*max 1600*** = # of months with mean monthly flows > 1,600 cfs
**SIV*max 2500*** = # of months with mean monthly flows were > 2,500 cfs
**SIV*max 7200*** = # of days with Lake Okeechobee Zone A discharges > 7,200 cfs

Values range from 0.01 (the least desirable condition) to 1.0 (the most desirable condition).

**Variable SIV*min***. This variable is based on the number of months the mean monthly flow from the lake and watershed fall below 350 cfs for the 1965-1995 period. The target is to have no more than 50 months with mean monthly flow less than 350 cfs for this period of analysis.

**Principal Objective**: This variable addresses the importance of low flow conditions (mean monthly flows<350cfs). The objective is to maintain sufficient minimum mean monthly flows in order to maintain favorable conditions for estuarine organisms. This includes the importance of fresh water and nutrient input into the system in the appropriate quantity and timing to support primary and secondary productivity (discussed in more detail in the following paragraphs).

**Rationale**: Insufficient freshwater discharges during the dry season contribute to reduced estuarine productivity. Minimum levels of inflow and nutrients usually occur at the end of the dry season (April and May). It is during these months that numerous species of juvenile fish depend on an abundant food supply of phytoplankton and zooplankton which requires a minimum level of fresh water and nutrients. In order for the estuary to act as a nursery for juvenile fish, plankton populations should be at a high enough density for fish to easily feed.

The target salinity gradients in St. Lucie Estuary were determined by a hydrodynamic salinity model (Morris 1987) combined with estimates of salinity requirements for two indicator species in the estuary, Halodule wrightii (shoal grass) and Crassostrea virginica (American oyster). Target minimum mean monthly flows to the estuary are 350 cfs to protect oysters near the Roosevelt Bridge, promote brackish aquatic plant growth, and support juvenile fish populations. This flow could come from the watershed (including groundwater), Lake Okeechobee (via S-80), or a combination of the two.

**Outputs for SIV*min***: As stated above, the ROGEM indices are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling indicate that the optimum senario would have no more than 50 months of mean monthly flows of <350 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target )}}$$

Note: The output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*min* are presented in Table St. Lucie Estuary - 1.

**Variable SIV*max1600:*** This variable is based on the number of months that mean monthly flow exceeds 1,600 cfs as measured from the lake and the watershed for the 1965-1995 period of record. The acceptable violations (target) allowing for natural variation is nine for the 1965-1995 period of record.

**Principal Objective**: Reduce high volume discharge events to the estuary to improve estuarine water quality and protect and enhance estuarine habitat and biota.

**Rationale**: Recent analysis has determined that mean monthly flow should not frequently exceed 1,600 cfs. As flows exceed this limit, the salinity is reduced below desirable levels for some estuarine resources. Also, high volume discharges to the estuary contribute to poor estuarine water quality including increased turbidity, and violation of the favorable salinity envelope. These events have direct effects on SAV by reducing light penetration necessary for photosynthesis, degrading fish and invertebrate habitat, and contributing to unfavorable salinity concentrations for aquatic vegetation, fish and invertebrates, including the indicator species (American oyster and SAV).

**Outputs for SIV*max1600:*** As stated above, the ROGEM scores are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling of this period indicate that the optimum scenario would have no more than nine months of mean monthly flows of >1600 cfs. The St. Lucie Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target )}}$$

Note: The maximum output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*max1600* are presented in Table St. Lucie Estuary - 1.

**Variable SIV*max2500:*** This variable measures the number of times mean monthly flows from the lake and watershed exceeds 2,500 cfs for the 1965-1995 period of record. The target is no more than three months with men monthly flows > 2500 cfs for the 1965-1995 period of record.

**Principal Objective**: Reduce the occurrence of extreme discharge events and improve water and sediment quality in the estuary to protect estuarine vegetation, invertebrates, and fish communities.

**Rationale**: Mean monthly flows above 2,500 cfs result in freshwater conditions throughout the entire estuary causing severe impacts to estuarine biota. This volume of flow begins to impact the Indian River Lagoon to the north and south of the St. Lucie Inlet.

**Outputs for SIV*max2500:*** The ROGEM scores are ordinal numbers. The total allowable number of monthly violations, based on natural variation of hydrologic conditions, and hydrologic modeling of this period indicate that the optimum condition is to have no more than three months of mean monthly flows of >2500 cfs. The St. Lucie Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target )}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions

Results for SIV*max2500* are presented in Table St. Lucie Estuary - 1.

**Variable SIV*max7200:*** This variable is based on the number of days of Zone A discharge from the Lake, (7,200 cfs per day at S-80) for each alternative for the period 1965-1995. The target is zero (0) violations. Because of the magnitude of Zone A releases on the environment, this variables is the highest priority of the four ROGEM variables and would normally have been weighted in the overall ROGEM equation. However, since alternatives A – D13R eliminate all except for two days of the Zone A releases, this variable was not weighted.

**Principal Objective**: Eliminate the occurrence of extreme discharge events from the lake to the estuary, and improve estuarine water quality in order to protect existing and potential habitat for estuarine vegetation, invertebrates, and fish communities.

**Rationale**: Zone A discharges transport large amounts of sediment and results in freshwater conditions within the entire estuary. These events can have rapid and serious effects on estuarine SAV by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat. They contribute to unfavorable salinity concentrations for most aquatic life, including the American oyster and SAV, as well as contributing to the occurrence and severity of fish diseases. These large volume discharges also cause adverse effects on large areas of the Indian River Lagoon surrounding the St. Lucie Inlet and possibly influence nearshore ocean habitats adjacent to the Inlet. Prolonged Zone A discharges result in even greater damage to the various ecosystems, and more widespread adverse effects.

**Outputs for SIV*max7200***: No Zone A discharges of this magnitude are desirable. Furthermore, the results of hydrologic modeling of the period 1965-1995 indicate that no daily flows of >7200 cfs would have occurred during this period. The estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of days}}{\text{range (observed max \# days for all alts )}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates maximum conditions.

Results for SIV*max7200* are presented in Table St. Lucie Estuary - 1.

**ROGEM equation and final scores for St. Lucie Estuary**

The variables can be prioritized from lowest to highest, according to the following: SIVmin is the lowest priority variable, followed by SIVmax 1600, which is lower than SIVmax 2500, which is followed by SIVmax7,200 (Zone A regulatory releases >7,200 cfs from Lake Okeechoobee, the highest priority variable for St. Lucie. Note, however, that all these variables/performance measures are considered first order priority variables even though it is possible to rate them relatively among each other. All variables are weighted equally in the ROGEM equation.

ROGEM scores are calculated according to the following:

$$1/4\ (\text{SIV}\mathit{min} + \text{SIV}\mathit{max1600} + \text{SIV}\mathit{max2500} + \text{SIV}\mathit{max7200})$$

Scores for all of the plans and the two bases are presented in the attached table. To summarize: alternatives A through D all scored 0.8 on a scale of 0.0 to 1.0. The St. Lucie subteam agrees that any of the alternatives would be considered fair for St. Lucie Estuary. The principle reason for this is that the basin runoff results are still about 4 times greater than their targets. The reason that the ROGEM score was 0.8 was because the regulatory release and low-flow targets were almost met.

While there is very little difference between alternatives A through D they all show improvements over the 1995 Base, which scored 0.0, and the 2050 Base, which scored 0.1. Because most regulatory releases were eliminated in plans A through D, SIV*max7200* was not weighted more heavily than the other variables. However, if the plans had not been so successful in eliminating the Zone A regulatory discharges then SIV*max7200* would have been weighted.

NEED D13R INFO HERE

**Lake Worth Lagoon**

The performance measure used in this analysis for the Lake Worth Lagoon was "Wet/Dry season average flows discharged to Lake Worth Lagoon through S-40, S-41, and S-155 for the 31 year simulation." The restoration target is to create estuarine conditions, to the extent possible, in the Lake Worth Lagoon. An estuarine salinity envelope of 23 ppt to 35 ppt has been chosen as the target salinity range. This is a viable salinity range for a number of organisms many of that are commercially and recreationally important. To attain this salinity a maximum flow needed to be developed. Previous hydrodynamic modeling displayed that 500 cfs creates a steady state salinity of 23 ppt. For the low flow part of the salinity envelope, 0 cfs is the target. Enough ground water occurs that should still allow estuarine conditions. Based on past modeling, this flow range of 0-500 cfs should create the salinity range of 23 ppt - 35 ppt.

**The following protocol was used for the Lake Worth Lagoon:**
Ranking: The alternatives and bases were ranked from 1-5 (one being best, see Table Lake Worth Lagoon - 1). Alternatives A, B, C, D, and the 2050 Base were ranked. The rankings for the two performance measures were added and Alternative B was best, followed by C, than D and A, and lastly the 2050 Base. After closely examining the model output, the minimum flow performance criteria for D has a number of small releases that are above 0 cfs, but small enough that they do not effect the estuaries salinity. So in actuality D is probably tied with C in the ranking.

Colors: None of the alternatives were colored green. Alternatives B, C, and D were colored yellow and A, 2050 Base, and 1995 Base were colored red.

Grades. Alternative B was graded a B, alternatives C and D were graded a C, Alternative A was a D, and the 2050 Base and 1995 Base were graded an F. Once again, Alternative D was probably very close to a B after reviewing the model output.

Alternative D13R has the same numbers as D and so would be ranked, colored, and graded the same.

## Biscayne Bay Surface Subteam Water Budget Matrix Documentation

### Geographical Region

For the purposes of this evaluation, Biscayne Bay is considered to be bounded by Snake Creek to the north (Oleta River State Park) and the southern border of Biscayne National Park to the south. Influence of proposed water management alternatives on Card and Barnes sounds to the south of Biscayne Bay will be considered as part of the Model Lands Other Project Element.

### Derivation of Performance Measures

Based on historical accounts and scientific studies, Biscayne Bay has been classed as a positive, shallow, tidal, bar-built estuary (Kohout and Kolipinski 1967). The term positive refers to the condition of salinity being less than seawater (Hela et al. 1957). The salinity gradient that established estuarine habitat in Biscayne Bay is dependent on both surface and ground water flows (Fatt and Wang 1987). The effect of regional drainage projects on these flows has been to disrupt salinity patterns and impair coastal ecosystem function by altering the timing and amounts of freshwater input to the bay.

Historically (pre-1910), freshwater input to the bay was through numerous coastal streams, sloughs, and springs and from wet season sheetflow flow to the tidal zone. Currently, ground water and surface water flow to the bay that contributed to estuarine salinities is reduced and hydroperiods have been altered. Surface water input to the bay is now intercepted and delivered through 14 regulated canals that are characterized by high amplitude, short duration storm flows during the wet season and low base flow during the dry season.

While accomplishing the goal of flood control, the presence and operation of the canals has had profound hydrological and ecological consequences on Biscayne Bay (Teas et al. 1976, Thorhaug et al. 1976, Hoffmeister 1974). The temporal and spatial pattern of freshwater inflow to the bay was fundamentally altered to one of point source discharges (canal mouths) that are characterized by abrupt periods of high discharge and minimal or no discharge to the bay. Although the general pattern of wet and dry seasons still persist, operation of coastal water control structures results in rapid changes in local salinity gradients that may occur on a daily basis and over several months, particularly during the rainy season (Fatt 1986). During the dry season, hypersalinity has been observed as a result of evaporation, retention of canal flow, and bay circulation (Lee 1975). While abrupt changes in salinity can occur naturally in nearshore habitats, they usually result from infrequent events such as hurricanes and tropical storms. The effects of salinity changes have been documented for fish (e.g. Davenport & Vahl 1975, Provencher et al. 1993, Serafy et al. in press) and for invertebrates (e.g. Brook 1982, Montegue and Ley 1993, Irlandi et al. in press). The presence and operation of the canals and construction of permanent oceanic inlets has resulted in a loss of estuarine function and shifted Biscayne Bay to more of a lagoon, adversely impacted from freshwater pulses and highly variable salinities. These conditions have been at least partly responsible for the loss of historically abundant estuarine species, such as red drum, black drum, and eastern oyster, the loss of juvenile fish habitat, and the significant increase in stress-tolerant fish species such as the gulf toadfish (Serafy et al., in press).

Biscayne Bay ecosystem restoration plans were initially considered by the South Florida Water Management District in a planning process that resulted in a water management plan, Surface Water Improvement and Management Plan for Biscayne Bay (SWIM Plan, Alleman 1995). This document provides a detailed discussion and analysis of water management needs in the Biscayne Bay watershed, including initial restoration plans for canal flow redistribution. It clearly outlines the rational for 1) reducing excessive canal discharges by flow management, 2) providing a stable brackish water habitat during the wet season, and 3) providing more water during dry periods to prevent hypersaline conditions from impacting important marginal wetlands and nearshore habitats. It also outlines research needs to further refine restoration designs and actions. Based on this plan and the consensus of government resource managers and university researchers, performance measures that would promote restoration of the Biscayne Bay ecosystem were established to permit evaluation of proposed water management alternatives.

**Performance Measures**

Performance measures were developed based on the potential effect of water management alternatives on surface water reaching Biscayne Bay. Canal discharges from gauged structures on canals that discharge into the bay were used. Based on SFWMM hydrologic model output, the bay was divided into five regions from north to south, based on the mean monthly discharge from water control structures in these regions. The regions were Snake Creek (S29), North Bay (G58, S28, S27), Miami River (S25, S25B, S26), Central Bay (G97, S22, S123), and South Bay (S21, S21A, S20F, S20G). Model output for each alternative provides results as the sum of discharge from the structures in each region in terms of a mean annual wet season and dry season volume. To judge the performance of a water management alternative in meeting restoration targets, model results were compared to surface water budget targets that were considered appropriate to achieving restoration of the Biscayne Bay ecosystem. These targets consist primarily of the existing average annual inflow to Biscayne Bay as defined by the 1995 Base hydrologic period, with a 2% increase in total inflow budget to be applied in the dry season to the Central and South Bay regions. A separate target for Snake Creek (S29) was also developed based on canal discharge that would maintain salinities for oyster survival.

Performance of individual alternatives was scored by comparing the predicted mean annual discharge for each alternative to the appropriate target for each region. A straight proportion of achieving the target was used to represent the degree to which the alternative achieved the target value, scaled from 0.0 to 1.0, for wet season, dry season, and for the total mean annual flow for that region. In instances for which an alternative exceeded the target, the score was automatically set to 1.0. An overall (total) bay performance measure was calculated using the total bay inflow from each of the regions defined by the SFWMM model.

**Performance Evaluation**

The scores in the following matrix are to be used only to rank the performance of the regional water management alternative in terms of supplying surface water to Biscayne Bay. They assume all components, especially the use of 're-use' water in alternatives C and D, are present. This refers to the use of 're-used' water or tertiary-treated domestic wastewater to replace water that will be withdrawn from the existing water management plan. The assumption that is implicit is that ‘re-used’ water will be both available and appropriate for use in a valuable, pristine, marine environment that sustains Biscayne National Park. Additional feasibility studies must be pursued and completed before any component of an alternative will be considered appropriate. The use of this matrix does not constitute endorsement of any of the alternatives.

Biscayne Bay currently receives surface water in amounts that will, when properly distributed, permit partial restoration of the coastal ecosystem. Therefore, matrix scores for the bay that are less than 1.0 indicates a potential adverse impact to wildlife and fishery resources in the bay and in Biscayne National Park. Alternative D performs the best in terms of available water, but in terms of total bay inflow, Alternative D does not improve conditions for restoration beyond currently existing (1995 Base) conditions. As such, all alternatives currently proposed are considered as having a negative effect on the potential of achieving restoration of the Biscayne Bay ecosystem.

The following is a summary of water management alternative performance scores based on a comparison between SFWMM model output and restoration targets for mean annual surface water budgets for bay regions and for the total bay freshwater input.

| | **1995 Base** | **2050 Base** | **Alternative A** | **Alternative B** | **Alternative C** | **Alternative D** |
|---|---|---|---|---|---|---|
| **North Bay** | | | | | | |
| Dry Season | 1.00 | 0.90 | 0.51 | 0.93 | 0.93 | 0.93 |
| Wet Season | 1.00 | 0.96 | 0.52 | 0.97 | 0.98 | 0.98 |
| Annual | 1.00 | 0.94 | 0.51 | 0.96 | 0.96 | 0.96 |
| **Snake Creek** | | | | | | |
| Dry Season | 0.55 | 0.46 | 0.15 | 0.31 | 0.33 | 0.30 |
| Wet Season | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 1.00 |
| Annual | 1.00 | 0.98 | 0.44 | 0.70 | 0.74 | 0.69 |
| **Miami River** | | | | | | |
| Dry Season | 1.00 | 0.65 | 0.40 | 0.45 | 0.37 | 0.32 |
| Wet Season | 1.00 | 0.62 | 0.55 | 0.39 | 0.33 | 0.33 |
| Annual | 1.00 | 0.63 | 0.50 | 0.41 | 0.34 | 0.33 |
| **Central Bay** | | | | | | |
| Dry Season | 0.77 | 0.88 | 0.29 | 0.49 | 0.59 | 0.76 |
| Wet Season | 1.00 | 0.94 | 0.53 | 0.65 | 0.75 | 0.87 |
| Annual | 0.92 | 0.92 | 0.45 | 0.60 | 0.69 | 0.83 |
| **South Bay** | | | | | | |
| Dry Season | 0.76 | 0.76 | 0.57 | 0.60 | 1.00 | 1.00 |
| Wet Season | 1.00 | 0.96 | 0.77 | 0.79 | 1.00 | 1.00 |
| Annual | 0.93 | 0.90 | 0.71 | 0.73 | 1.00 | 1.00 |

**BISCAYNE BAY GROUNDWATER EVALUATION**

**Groundwater Index =** Measure of the degree to which groundwater levels produced by each alternative match projected comparison conditions (NSM = primary comparison, Ghyben-Herzburg relationship for that indicator region = minimum target). Groundwater flows into Biscayne Bay are potentially important as a source of freshwater. Under conditions where high water stages occurred west of the Atlantic Coastal Ridge to within three miles of Biscayne Bay, historic groundwater flows were sufficient to support flowing springs that allowed the collection of drinking water for ships (Parker et al. 1955). Present day rates of groundwater discharge are evidently insufficient to produce such flowing springs (Mulliken and VanArman 1995). The desired groundwater levels for restoration are those that match historic conditions. The minimum acceptable groundwater levels to support the Biscayne Bay estuary are those sufficient to eliminate salt water intrusion to the Biscayne Aquifer, as theoretically measured by the Ghyben-Herzburg relationship.

The groundwater indicator regions are located at the edge of the SFWMM grid, and output results for NSM are, therefore, not accurate. They do, however, provide a relative measure for current vs. historical groundwater levels and are, therefore, a reasonable approximation for the direction in which groundwater levels should be restored in order to return historic groundwater flows to Biscayne Bay.

Since groundwater values were normalized to ground elevation, they are negative numbers and direct comparisons are difficult. Two indices were defined, therefore, to create proportional relationships that could be compared. The first index looks at the midpoint of the stage duration curve, and the second index uses the values representing the 90$^{th}$ percentile of the stage duration curve. The midpoint was chosen to give an indication of the relative performance of the alternatives under moderate conditions. The 90$^{th}$ percentile comparison gives an indication of the relative performance of the alternatives under severe drought conditions. NSM values consistently represented the wet extreme of the modeling scenarios, and one or more alternatives represented the dry extreme. The index sets up a comparison between the absolute difference between a particular alternative and NSM and the absolute difference between the dry and wet extremes, i.e. the worst alternative and NSM. The index values vary from 0 to 1, with 1 equal to NSM conditions and 0 equal to the worst alternative.

**Indicator Regions Covered**: 48, 49, 50, 51

**Formula**:

The following formula sets up a proportional relationship showing the relative wetness of the alternative when compared to the range available. The index values vary from 0 to 1, with 1 equal to NSM conditions and 0 equal to the worst alternative.

Groundwater Index 1 = 1 - [(alternative value at 50% mark of stage duration curve)-(NSM value at 50% mark of stage duration curve)]/[(worst alternative value at 50% mark of stage duration curve)-(NSM value at 50% mark of stage duration curve)]

Minimum Target 1 = 1- [(low water target value for indicator region)-(NSM value at 50% mark of stage duration curve)]/[(worst alternative value at 50% mark of stage duration curve)-(NSM value at 50% mark of stage duration curve)]

Groundwater Index 2 = 1 - [(alternative value at 90% mark of stage duration curve)-(NSM value at 90% mark of stage duration curve)]/[(worst alternative value at 90% mark of stage duration curve)-(NSM value at 90% mark of stage duration curve)]

Minimum Target 2 = 1 - [(low water target value for indicator region)-(NSM value at 90% mark of stage duration curve)]/[(worst alternative value at 90% mark of stage duration curve)-(NSM value at 90% mark of stage duration curve)]

**Note**: For Indicator Region 51 (South Biscayne Bay), the NSM value was less than the low water target at the 90$^{th}$ percentile, so the equation for this indicator region was changed to use the low water target as the standard for comparison. The equation for this indicator region was:

Groundwater Index 2 (IR51) = 1 - [(alternative value at 90% mark of stage duration curve)-(low water target for IR51)/(worst alternative value at 90% mark of stage duration curve)-(low water target for IR51)]

and the minimum index for comparison was:

Minimum Target 2 (IR51) = 1 - [(low water target value for IR51)-(low water target for IR51)]/[(worst alternative value at 90% mark of stage duration curve)-(low water target for IR51)]

**Summary Matrix**:

The summary matrix was derived by averaging the results from each indicator region for each alternative. Values for the Central and South Biscayne Bay indicator regions (IR50, IR51) were weighted more heavily in the analysis by adding them twice into the average. This weighting system was selected to give priority to alternatives that improved conditions within Biscayne National Park. NSM values were not included because NSM values were presented for comparison purposes only; it is not a target.

**Interpretation**:

The matrix for the 50$^{th}$ percentile of the stage duration curves shows almost no difference among the alternatives. The raw index scores varied from 0.000 to 0.080 on a scale of 0 to 1. None of the alternative scores exceeded the low water target for that region, although Alternative D in IR50 came closer than any other scenario. For three of the four indicator regions, the 95Base conditions were the best among the alternatives. When the indices were averaged, 95Base conditions were slightly better than Alternatives C and D, though the separation among the three was very small. These results indicate that under average conditions, almost nothing in the Restudy has had any effect on groundwater elevations near the Atlantic Coastal Ridge, and nothing proposed to date in the Restudy has made any difference with respect to restoring groundwater flows to Biscayne Bay. Results for Alternative D13 were identical to those for Alternative D.

The matrix for the 90$^{th}$ percentile of the stage duration curves shows some differences among the alternatives. The 90$^{th}$ percentile represents conditions of severe drought, and any improvement in this part of the curve over base conditions would probably mean some maintenance of groundwater flows under drought conditions. The raw index scores varied from 0.000 to 0.463, with the low water target index at 1.000 for comparison. The alternative with the best scores varied by indicator region, but 95Base, Alternative C and Alternative D were usually close, except for Central Biscayne Bay (IR50), where 95Base was clearly the worst alternative. Alternative B produced moderately good results for IR48 and IR50. When the indices were averaged, however, Alternatives C and D came out much better than base conditions or Alternative B, with Alternative D performing slightly better than Alternative C. The provision of additional water appears to help maintain groundwater levels in the region during extreme drought conditions, and may play an important role in maintaining some degree of groundwater flow to

Biscayne Bay during periods of extreme drought. Results for Alternative D13 were identical to those for Alternative D.

It should be emphasized that these conclusions were made on the basis of a very small improvement to groundwater conditions under severe drought conditions. None of the alternatives come close to meeting the minimum water level targets set for the indicator regions. The overall conclusion must be that although Alternatives D/D13 perform better than the other alternatives, nothing proposed to date in the Restudy has made a significant difference with respect to restoring groundwater flows to Biscayne Bay. It is hoped that additional means for improving groundwater flows will be sought and implemented as part of the design phase of the project.

**Notes on Biscayne Bay Groundwater Matrix Interpretation**

It is clear from these results that additional water sources can make a noticeable contribution toward maintaining groundwater levels for Central and South Bay during drought conditions. These results mirror effects seen in the surface water output. The source of the water is, however, a concern. Treated wastewater has not yet been unequivocally shown to be an economically and environmentally feasible alternative, and dependence upon this source to supplement water supplies to the bay could prove short sighted, should it be eliminated as a source in the future. It is strongly recommended, therefore, that alternative sources of water be identified during the design phase that could be used to provide water deliveries for the bay.

**Notes on Biscayne Bay Surface Water Matrix Interpretation**

The alternatives analysis has only addressed surface water timing issues in a very superficial manner and only in the vicinity of Biscayne National Park. More needs to be done to address this problem in the more urbanized areas of the bay.

The alternatives analysis has not adequately addressed water quality issues for either surface water or groundwater moving to the bay. In areas where less surface water is delivered to the bay via canals, pollutants from urban sources are likely to increase in concentration. This is a particularly formidable problem in the Miami River, where the source for many pollutants is well downstream from where water is being stored (the Lakebelt Reservoir). By the time the river water is discharged into the bay, the large reduction in volume may result in a substantial increase in pollutant concentration. More attention should be given to addressing such concerns prior to finalizing a project design.

**References**:

Mulliken, , J.D. and J.A. VanArman, eds. 1995. Biscayne Bay Surface Water Improvement and Management Technical Supporting Document. South Florida Water Management District, West Palm Beach, FL. 178 Pp. plus appendices.

Parker, G.G., G.E. Ferguson, S.K. Love, and others. 1955. Water Resources of Southeastern Florida. Water Supply Paper 1255. U.S. Geological Survey, Washington, D.C. 965 Pp.

**Biscayne Bay Evaluation Matrix, by Indicator Region,**
**Final Draft 7/31/98**

Values vary from 0 to 1, with larger values preferred. Preferred alternatives produce index values greater than the minimum index value for that percentile.

| Indicator Region: 48 (North Biscayne Bay Groundwater 1) | Alt # | Raw Value, 50% | G.W. Index 1 (50%) | Min.Index 1 (50%) | Rank by Region | Raw Value, 90% | G.W. Index 2 (90%) | Min. Index 2 (90%) | Rank |
|---|---|---|---|---|---|---|---|---|---|
| Low Water Target | | -5.11 | | | | -5.11 | | | |
| Worst Alternative Value | 50Base | -7.65 | | | | -8.00 | | | |
| NSM | | -2.00 | 1.000 | 0.450 | | -4.45 | 1.000 | 0.814 | |
| 95Base | | -7.50 | 0.027 | 0.450 | 1 | -7.85 | 0.042 | 0.814 | 1 |
| 50Base | | -7.65 | 0.000 | 0.450 | 3 | -8.00 | 0.000 | 0.814 | 3 |
| Alternative A | | -7.65 | 0.000 | 0.450 | 3 | -8.00 | 0.000 | 0.814 | 3 |
| Alternative B | | -7.60 | 0.009 | 0.450 | 2 | -7.95 | 0.014 | 0.814 | 2 |
| Alternative C | | -7.60 | 0.009 | 0.450 | 2 | -7.95 | 0.014 | 0.814 | 2 |
| Alternative D/D13 | | -7.60 | 0.009 | 0.450 | 2 | -7.95 | 0.014 | 0.814 | 2 |

| Indicator Region: 49 (North Biscayne Bay Groundwater 1) | Alt # | Raw Value, 50% | G.W. Index 1 (50%) | Min.Index 1 (50%) | Rank by Region | Raw Value, 90% | G.W. Index 2 (90%) | Min. Index 2 (90%) | Rank |
|---|---|---|---|---|---|---|---|---|---|
| Low Water Target | | -5.00 | | | | -5.00 | | | |
| Worst Alternative Value | Alt A | -6.00 | | | | -6.45 | | | |
| NSM | | -0.15 | 1.000 | 0.171 | | -2.65 | 1.000 | 0.382 | |
| 95Base | | -5.90 | 0.017 | 0.171 | 1 | -6.35 | 0.026 | 0.382 | 1 |
| 50Base | | -6.00 | 0.000 | 0.171 | 2 | -6.40 | 0.013 | 0.382 | 2 |
| Alternative A | | -6.00 | 0.000 | 0.171 | 2 | -6.45 | 0.000 | 0.382 | 3 |
| Alternative B | | -6.00 | 0.000 | 0.171 | 2 | -6.35 | 0.026 | 0.382 | 1 |
| Alternative C | | -6.00 | 0.000 | 0.171 | 2 | -6.35 | 0.026 | 0.382 | 1 |
| Alternative D/D13 | | -6.00 | 0.000 | 0.171 | 2 | -6.35 | 0.026 | 0.382 | 1 |

| Indicator Region: 50 (Central Biscayne Bay Groundwater) | Alt # | Raw Value, 50% | G.W. Index 1 (50%) | Min.Index 1 (50%) | Rank by Region | Raw Value, 90% | G.W. Index 2 (90%) | Min. Index 2 (90%) | Rank |
|---|---|---|---|---|---|---|---|---|---|
| Low Water Target | | -7.51 | | | | -7.51 | | | |
| Worst Alternative Value | Alt A(50), 95B | -7.85 | | | | -8.70 | | | |
| NSM | | -4.35 | 1.000 | 0.097 | | -6.40 | 1.000 | 0.517 | |
| 95Base | | -7.65 | 0.057 | 0.097 | 2 | -8.70 | 0.000 | 0.517 | 5 |
| 50Base | | -7.70 | 0.043 | 0.097 | 3 | -8.60 | 0.043 | 0.517 | 4 |
| Alternative A | | -7.85 | 0.000 | 0.097 | 5 | -8.60 | 0.043 | 0.517 | 4 |
| Alternative B | | -7.80 | 0.014 | 0.097 | 4 | -8.50 | 0.087 | 0.517 | 3 |
| Alternative C | | -7.65 | 0.057 | 0.097 | 2 | -8.20 | 0.217 | 0.517 | 2 |
| Alternative D/D13 | | -7.60 | 0.071 | 0.097 | 1 | -8.10 | 0.261 | 0.517 | 1 |

| Indicator Region: 51 (South Biscayne Bay Groundwater) | Alt # | Raw Value, 50% | G.W. Index 1 (50%) | Min.Index 1 (50%) | Rank by Region | Raw Value, 90% | G.W. Index 2 (90%) | Min. Index 2 (90%) | Rank |
|---|---|---|---|---|---|---|---|---|---|
| Low Water Target | | -2.97 | | | | -2.97 | | | |
| Worst Alternative Value | Alt A | -3.27 | | | | -4.05 | | | |
| NSM | | -1.55 | 1.000 | 0.174 | | -3.45 | 0.556 | 1.0 | |
| 95Base | | -3.13 | 0.081 | 0.174 | 1 | -3.85 | 0.185 | 1.0 | 2 |
| 50Base | | -3.23 | 0.023 | 0.174 | 3 | -4.05 | 0.000 | 1.0 | 4 |
| Alternative A | | -3.27 | 0.000 | 0.174 | 5 | -4.05 | 0.000 | 1.0 | 4 |
| Alternative B | | -3.25 | 0.012 | 0.174 | 4 | -3.95 | 0.093 | 1.0 | 3 |
| Alternative C | | -3.15 | 0.070 | 0.174 | 2 | -3.55 | 0.463 | 1.0 | 1 |
| Alternative D/D13 | | -3.15 | 0.070 | 0.174 | 2 | -3.55 | 0.463 | 1.0 | 1 |

**Biscayne Bay Evaluation Matrix Summary, Final Draft 5/27/98**

| Alternative #: | 95BSR | 50BSR | Alt A | Alt B | Alt C | Alt D |
|---|---|---|---|---|---|---|
| 50th Percentile Average Index*: | 0.053 | 0.022 | 0.000 | 0.010 | 0.044 | 0.049 |
| 50th Percentile Rank: | 1 | 3 | 5 | 4 | 2 | 2 |
| | | | | | | |
| 90th Percentile Average Index*: | 0.073 | 0.017 | 0.014 | 0.067 | 0.234 | 0.248 |
| 90th Percentile Rank: | 2 | 3 | 3 | 2 | 1 | 1 |

*Central and South Biscayne Bay Regions given a weight of 2 each for averaging in consideration of National Park issues.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total** | | | | | | |
| Dry Season | 0.78 | 0.71 | 0.35 | 0.51 | 0.66 | 0.73 |
| Wet Season | 1.00 | 0.96 | 0.63 | 0.75 | 0.85 | 0.93 |
| **Annual** | **0.98** | **0.87** | **0.53** | **0.66** | **0.78** | **0.86** |

**NEED EVALUATION OF D13R**

## I. Keystone / Endangered Species / ATLSS

Performance Based Comments:

For Alternative D13R ATLSS high resolution hydrology results and breeding potential index, individual-based simulation and Population Viability Analysis results for the Cape Sable seaside sparrow are available. Fish abundance, snail kite foraging conditions index, wading bird foraging conditions index and white-tailed deer breeding potential index results are also available. American crocodile performance measure results are available as usual.

Performance:

Fish

The ATLSS fish model results have consistently predicted higher overall fish abundances as flow volume and inundation duration have moved closer to NSM conditions. Continuing this trend, ATLSS results suggest that Alternative D13R hydrologic conditions should produce average fish abundances higher than those expected for 2050 Base, and slightly higher than other Alternatives as expected hydroperiods increase consistent with NSM. In particular, increased hydroperiods in NE Shark River Slough, Taylor Slough, WCA-3B, northeast WCA-3A, and WCA-1 should lead to greater fish abundance. This is also true when only prey-sized fish at appropriate wading bird foraging depths are counted except for the deepest parts of Shark River Slough and WCA-3B.

Wading Birds

Alternative D13R reduces many of the excessive high water conditions and excessive inundation durations that had caused concern for eastern WCA-3A, southern WCA-3A and WCA-3B in several previous alternatives. These improvements should provide relatively larger areas suitable for wading bird foraging and decreased flood-induced losses of wading bird nesting substrates in WCA-3 under Alternative D13R as compared to Alternative D. When compared to the 2050 Base,Alternative D13R provides mixed results for wading birds in WCA-3, with improvements in southern WCA-3A (due to reduced high water) and in northern WCA-3A (due to reduced drydowns), and losses in northeastern WCA-3A and WCA-3B (due to increased high water).

Results for the southern Everglades and for Florida Bay also indicate that Alternative D13R better matches natural conditions in these areas than other Alternatives. The improvement in the timing and duration of freshwater flows to Florida Bay estuaries and improved timing of food-concentrating drydowns should lead to better wading bird foraging and breeding conditions in the southern Everglades under Alternative D13R relative to both base cases. reater fish abundances expected under Alternative D13R, as compared to the 2050 base, also suggest improved foraging conditions for wading birds.

Wood Storks

Since ATLSS long-legged wading bird results and a wood stork performance measure recently developed by John Ogden are used to evaluate wood stork responses under Alternative D13R. Both the ATLSS high resolution hydrology results and inspection of the Shark Slough inundation duration and mainland estuary flow volume information used in the performance measure reveal significant improvements in hydroperiods, volume and timing of flows under all Alternatives, including Alternative D13R as compared to 2050 Base. This should provide significantly improved forage availability in the Florida Bay estuaries that historically supported the majority of wood stork nesting, and may result in beneficial earlier nest initiation cues for wood storks. Comparison of Alternative D13R with Alternative D provides mixed results, with improved inundation duration in Shark Slough Indicator Region 10 but not Indicator Region9, and no significant difference for freshwater flows to Florida Bay estuaries. Therefore, Alternative D13R cannot be distinguished from Alternatives A-D in terms of wood stork habitat suitability.

Snail Kites

In general, comparison of hydrology expected under Alternative D13R vs. the 2050 base shows significant progress toward natural conditions represented by NSM. Such a shift towards more natural conditions produces a slight improvement in overall foraging conditions for snail kites due to an overall increase in extent of longer hydroperiod areas conducive to apple snail production, and a reduction in artificially impounded areas having persistent deep water that causes long-term loss of snail kite nesting substrates. Snail kite foraging habitat would probably shift from some current high-use areas such as WCA-2B and southern WCA-3A to central and eastern WCA-3A, northern WCA-3B and the flanks of Shark River Slough where Alternative D13R would provide longer hydroperiods suitable for sustained apple snail production. Benefits would be particularly apparent in low water years due to the overall increase in water available to the natural system under Alternative D13R and the snail kite's particular sensitivity to reduction of suitable foraging habitat during drought. Benefits to snail kites under Alternative D13R cannot be distinguished from those expected under Alternatives C and D. Expected benefits under Alternative D13R would probably not influence long term trends in the overall snail kite population because other habitats, outside the area modeled for Restudy alternatives, are thought to be more important to the species as a whole.

White-tailed Deer

Alternative D13R reduces many of the excessive high water conditions and excessive inundation durations that had caused concern for eastern WCA-3A, southern WCA-3A and WCA-3B in several previous alternatives. These improvements provide slightly better foraging conditions and reduced drowning losses for white-tailed deer in WCA-3 under Alternative D13R as compared to Alternative D. Overall increased hydroperiods in most of the WCAs and northeastern Big Cypress under Alternative D13R as compared to the 2050 base would slightly decrease habitat quality in these marginal deer habitats. Small areas of northeastern and southern WCA-3A and the Big Cypress-ENP border area are exceptions. Alternative D13R continues progress towards NSM-like conditions in most of ENP and would be expected to continue to produce reduced white-tailed deer habitat suitability in many already poor deer habitats there. For those few areas with high deer breeding potential (Long Pine Key and surrounding short hydroperiod marsh and NW Big Cypress), there is little difference between Alternative D13R and the 2050 Base.

Florida Panther

Review of the Alternative D13R ATLSS high resolution hydrology results shows that no change is expected in the higher elevation pine flatwood and hardwood hammock habitats preferred by Florida panthers. Additionally, discussions with panther experts Dennis Jordan and Sonny Bass (personal communications, June 1, 1998) indicate that slight reductions in the quality of already poor deer habitats, as expected under Alternative D13R, would not have an effect on panther populations.

Cape Sable Seaside Sparrow

Predicted results for Alternative D13R rely on ATLSS modeling results and April 24 and June 1, 1998, discussions with species experts Stuart Pimm, Sonny Bass, Phil Nott, and John Curnutt.

ATLSS Breeding Potential Index results showed consistently lower breeding potential for Cape Sable seaside sparrows in eastern habitats and in the southeastern part of the western subpopulation habitat under Alternative D13R as compared to Alternatives B, D and the 2050 Base. However, the sparrow Breeding Potential Index does not take population dynamics or fire return frequencies into account. When we factor in reductions in damaging fire return frequencies in the sparrow's eastern habitats expected to result from hydroperiod increases like those in Alternatives B-D and D13R, these Alternatives are likely to significantly improve sparrow habitat suitability in the eastern marl prairie areas. The central population is unlikely to be affected by any of the Alternatives due to its higher elevation.

The ATLSS individual-based sparrow model includes detailed simulations of population dynamics, and therefore provides better information on the expected effects of management scenarios than does the Breeding Potential Index. The ATLSS individual-based sparrow simulation is applied only to the western sub-population, and predicts persistence of this sub-population under Alternative D13R and the 2050 Base. Alternative D13R produced higher population levels and a lesser risk of extirpation than Alternatives B and D. A Population Viability Analysis using the individual model predicts that the western subpopulation will be more likely to remain above minimum numbers and reach or exceed maximum numbers under Alternative D13R than under Alternatives Band D or either base.

Overall, Alternative D13R should improve conditions for the Cape Sable seaside sparrow as compared to the 2050 Base, and will likely contribute to the recovery of this subspecies.

American Crocodile

The Crocodile habitat suitability performance measure shows that Alternative D13R would produce significantly lower salinity ranges in important Florida Bay crocodile habitats as compared to the 2050 Base. This should provide improved nursery habitat availability for hatchling crocodiles and increase availability of low salinity habitats preferred by adult crocodiles. These results are not distinguishable from those for Alternatives A-D.

Performance Measures and Indicators Used:

ATLSS High Resolution Hydrology
Breeding Potential Index for the Cape Sable seaside sparrow
Foraging Conditions Index for the snail kite
Foraging Conditions Index for short and long-legged wading birds
ATLSS Cape Sable seaside sparrow Individual-based Simulation
ATLSS Cape Sable seaside sparrow Population Viability Analysis
ATLSS Fish Model
American Crocodile Performance Measure
Wood Stork Nesting Patterns Performance Measure

Recommendations:
Continue development and use of ATLSS modeling as a tool for further planning, design and adaptive management.

Subteam Issues:

The sparrow west indicator region shows that NSM predicts longer hydroperiods in the western sub-population area that would lead to further declines in sparrow habitat suitability. The subteam urges Restudy participants to reconsider NSM-based targets when biological information, such as sparrow breeding needs, suggests different targets.

## J. Water Quality

**This section under development**

**ATTACHMENT A**

**References for Matrix Development**

**References Total System**


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